NOVEMBER 1953

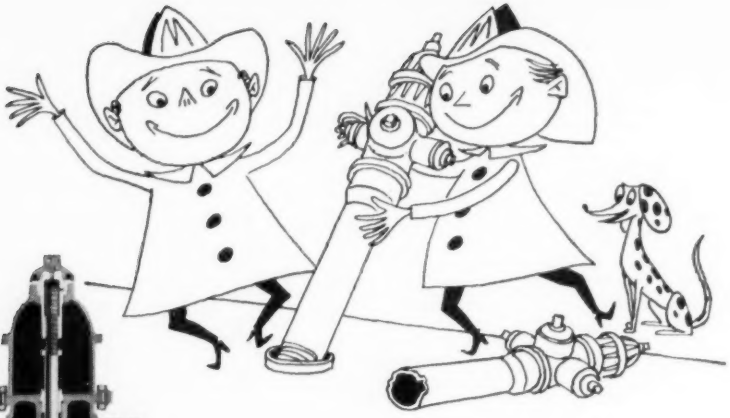
Journal

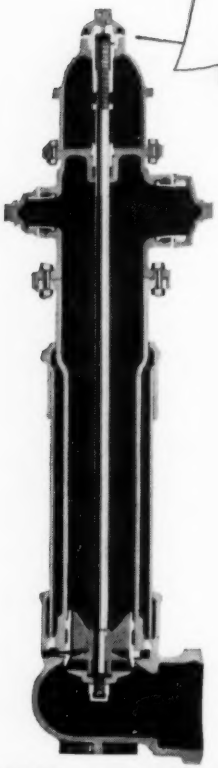
VOL. 45 • NO. 11

AMERICAN WATER WORKS ASSOCIATION

In this issue

Suburban Water Pressure	Williams, Finch
Meeting Dallas' Water Shortage	Hoefle, Krick
Fire Protection Service Rates	Ellis
Irrigation Runoff	Cunningham, Haney, Bendixen, Howard
Tastes and Odors	Silvey
Synthetic-Detergent Pollution	Culp, Stoltenberg
Molecular Filter Membrane Technique	Task Group Report
Employee Safety	LaDue
California Utilities Commission	Watters
Purification Plant Wastes	Dean
Algae Control	Matheson
Raising an Elevated Storage Tank	Draves





No other hydrant is so inexpensive to maintain— so quick and easy to repair

- **The Mathews Hydrant is so simply and soundly constructed that there's virtually nothing to go wrong.**
- **Only one point needs lubrication—the operating thread—and that only during routine inspections.**
- **A Mathews Hydrant broken in a traffic accident can be quickly repaired *without excavating* and nozzle levels can be adjusted with the same ease.**
- **For community fire protection, rely on Mathews Hydrants, the standard of the industry.**

MATHEWS HYDRANTS

Made by R. D. Wood Company

Public Ledger Building, Independence Square, Philadelphia 5, Pa.

Manufacturers of "Sand-Spun" Pipe (centrifugally cast in sand molds) and R. D. Wood Gate Valves

150th anniversary

NO OTHER HYDRANT OFFERS SO MANY ESSENTIAL FEATURES

Compression type valve prevents flooding • Head turns 360° • Replaceable head • Nozzle sections easily changed • Protection case of "Sand-Spun" cast iron for strength, toughness, elasticity • All operating parts contained in removable barrel • A modern barrel makes an old Mathews good as new • Available with mechanical-joint pipe connections

Journal

AMERICAN WATER WORKS ASSOCIATION

November 1953

Vol. 45 • No. 11

COPYRIGHT, 1953, BY THE AMERICAN WATER WORKS ASSOCIATION, INC.

Contents

Control of Water Pressure in Suburban Distribution Lines.....J. S. Williams 1123
Discussion.....Lewis S. Finch 1135
Water Works Civil Defense Manual Issued..... 1138
Meeting the Dallas Water Shortage.....K. F. Hoefle 1139
Cloud-seeding Operations at Dallas.....Irving P. Krick 1144
Additional-Cost Basis for Fire Service Rates.....Richard H. Ellis 1151
Effect of Irrigation Runoff on Surface Water Supplies
Morrison B. Cunningham, Paul D. Haney, Thomas W. Bendixen & C. S. Howard 1159
Relation of Irrigation Runoff to Tastes and Odors.....J. K. G. Silvey 1179
Synthetic-Detergent Pollution in Kansas
Russell L. Culp & Howard A. Stoltenberg 1187
Technique of Bacterial Examination of Water With Molecular Filter Membranes
Task Group Report 1196
The Problem of Public Employee Safety.....Wendell R. LaDue 1211
Public Utilities Commission Activities in California.....Frank F. Watters 1219
Purification Plant Waste Disposal
Committee Statement..... 1225
Disposal of Wastes From Filter Plants and Coagulation Basins
John B. Dean 1226
Algae Control in Small Water Plants.....D. H. Matheson 1238
Raising an Elevated Storage Tank.....Harry J. Draves 1245
Fluoridation Stand Reiterated by ADA..... 1248

Departments

Officers and Directors..... *2 P&R*
List of Advertisers..... *6 P&R*
Coming Meetings..... *10, 12 P&R*
Percolation and Runoff..... *33 P&R*
The Reading Meter..... *52 P&R*
Correspondence..... *56 P&R*
Condensation..... *62 P&R*
Section Meetings..... *74 P&R*
Service Lines..... *90 P&R*
Index of Advertisers' Products... *92 P&R*

Reproduction of the contents, either as a whole or in part, is forbidden, unless specific permission has been obtained from the Editor of this Journal. The Association is not responsible, as a body, for the facts and opinions advanced in any of the papers or discussions published in its proceedings.

Indexed annually in December; and regularly by *Industrial Arts Index and Engineering Index.*

Microfilm edition (for Journal subscribers only) by University Microfilms, Ann Arbor, Mich.

All correspondence relating to the publication of papers should be addressed to:

Harry E. Jordan, Secretary—521 Fifth Avenue, New York 17, N.Y.

$7.00 of members' dues are applied as a subscription to the Journal; additional single copies to members—50 cents; single copies to non-members—75 cents.

AMERICAN WATER WORKS ASSOCIATION
INCORPORATED

521 Fifth Avenue, New York 17, N.Y.
(*Telephone: MUrray Hill 2-4515*)

Board of Directors

		TERM ENDS
President	M. B. CUNNINGHAM, Oklahoma City, Okla.	1954
Past-President	CHARLES H. CAPEN, Wanaque, N.J.	1954
Vice-President	DALE L. MAFFITT, Des Moines, Iowa	1954
Treasurer	WILLIAM W. BRUSH, New York, N.Y.	1954
Ch. W.W. Practice Com.	LOUIS R. HOWSON, Chicago, Ill.	1954
Ch. W.W. Admin. Com.	WENDELL R. LADUE, Akron, Ohio	1954
Ch. Publication Com.	RICHARD HAZEN, New York, N.Y.	1954
Alabama-Mississippi Sec.	TIP H. ALLEN, Canton, Miss.	1956
Arizona Section	R. GAIL BAKER, Phoenix, Ariz.	1956
California Section	L. W. GRAYSON, Glendale, Calif.	1954
Canadian Section	W. D. HURST, Winnipeg, Man.	1955
Chesapeake Section	EDWARD S. HOPKINS, Baltimore, Md.	1954
Cuban Section	LUIS A. NUNEZ, Havana, Cuba	1954
Florida Section	C. F. WERTZ, Miami, Fla.	1954
Illinois Section	FRED G. GORDON, Chicago, Ill.	1954
Indiana Section	LEWIS S. FINCH, Indianapolis, Ind.	1955
Iowa Section	JOHN W. PRAY, Fort Dodge, Iowa	1956
Kansas Section	H. H. KANSTEINER, Leavenworth, Kan.	1955
Kentucky-Tennessee Sec.	CHARLES H. BAGWELL, Knoxville, Tenn.	1956
Michigan Section	LOUIS E. AYRES, Ann Arbor, Mich.	1956
Minnesota Section	R. A. THUMA, St. Paul, Minn.	1954
Missouri Section	WARREN A. KRAMER, Jefferson City, Mo.	1955
Montana Section	JOHN B. HAZEN, Butte, Mont.	1954
Nebraska Section	RALPH H. LANCASTER, Kearney, Neb.	1956
New England Section	FRED P. STRADLING, Bristol, R.I.	1956
New Jersey Section	GEORGE D. NORCOM, Red Bank, N.J.	1956
New York Section	JAMES C. HARDING, White Plains, N.Y.	1956
North Carolina Section	GEORGE S. RAWLINS, Charlotte, N.C.	1955
Ohio Section	A. A. ULRICH, Massillon, Ohio	1954
Pacific Northwest Sec.	CHARLES C. CASAD, Bremerton, Wash.	1956
Pennsylvania Section	L. S. MORGAN, Greensburg, Pa.	1956
Rocky Mountain Section	CHARLES G. CALDWELL, Santa Fe, N.M.	1955
Southeastern Section	R. B. SIMMS, Spartanburg, S.C.	1955
Southwest Section	EDWARD R. STAPLEY, Stillwater, Okla.	1954
Virginia Section	X. D. MURDEN, Portsmouth, Va.	1955
West Virginia Section	HENRY W. SPEIDEN, Morgantown, W.Va.	1955
Wisconsin Section	HAROLD LONDO, Green Bay, Wis.	1955
Manufacturer	EVERETT M. JONES, Philadelphia, Pa.	1956
Manufacturer	REGINALD F. HAYES, New York, N.Y.	1954
Manufacturer	HUBERT F. O'BRIEN, East Orange, N.J.	1955

Administrative Staff

Secretary	HARRY E. JORDAN
Exec. Asst. Secretary	RAYMOND J. FAUST
Asst. Secretary—Publications	ERIC F. JOHNSON

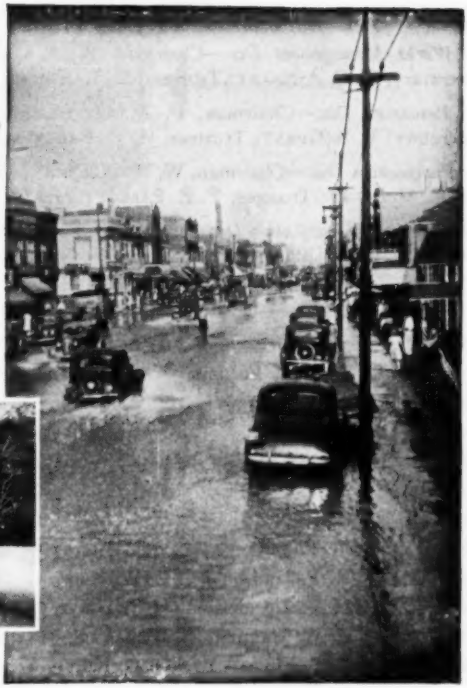
Journal AWWA is published monthly at Prince & Lemon Sts., Lancaster, Pa., by the Am. Water Works Assn., Inc., 521 Fifth Ave., New York 17, N.Y., and entered as second class matter Jan. 23, 1943, at the Post Office at Lancaster, Pa., under the Act of Aug. 24, 1912. Accepted for mailing at a special rate of postage provided for in paragraph (d-2), Section 34.40, P. L. & R. of 1948. Authorized Aug. 6, 1918.

Copyright, 1953, by the American Water Works Association, Inc.

Made in United States of America

WHERE PIPE LINES ARE CONCERNED...

It's never a lucky break



BELOW—Installing the 30" Lock Joint supply line for Ciudad Trujillo in the Dominican Republic. This line, undamaged by shocks which destroyed many structures in the vicinity, gave unimpaired service throughout the severe earthquake of 1946.

RIGHT—Damage attending the rupture of a large water main in a crowded community.

ONE SLIGHT FLAW IN A PIPE may develop the proportions of a major catastrophe when an important water line ruptures in a crowded area. Utilities can be impaired, property flooded, traffic stalled, business lost, life endangered. A bad break in more ways than one, but a break which could be avoided by using Lock Joint Pressure Pipe.

Lock Joint's water-tight expansion joints built into every section of pipe provide unrestrained flexibility under back loads to accommodate not only normal ground settlement but traffic vibrations and variations in temperature. The high factor of safety assured by its time-tested design of reinforcement provides for every pipe an abundant reserve against water hammer and pressure surges. Experience shows conclusively that Lock Joint Pressure Pipe does not fail.

When planning your next water supply main—specify Lock Joint Concrete Pressure Pipe—the pipe with a proven record of safety.

LOCK JOINT PIPE COMPANY

Est. 1905

P.O. Box 269, East Orange, N. J.

Pressure Pipe Plants: Wharton, N. J.
Turner, Kan. • Detroit, Mich. • Columbia, S. C.

BRANCH OFFICES: Casper, Wyo. • Cheyenne, Wyo. • Denver, Col. Kansas City, Mo. • Valley Park, Mo. • Chicago, Ill. • Rock Island, Ill. Wichita, Kan. • Kenilworth, N. J. • Hartford, Conn. • Tucumcari, N. M. Oklahoma City, Okla. • Tulsa, Okla. • Beloit, Wis. • Hato Rey, P. R.

SCOPE OF SERVICES—Lock Joint Pipe Company specializes in the manufacture and installation of Reinforced Concrete Pressure Pipe for Water Supply and Distribution Mains in a wide range of diameters from 16" up as well as Concrete Pipe of all types for Sanitary Sewers, Storm Drains, Culverts and Subaqueous Lines.

LOCK JOINT
Reinforced Concrete
PRESSURE PIPE

DIVISION AND SECTION OFFICERS

Officers of the Divisions

Water Works Management Div.—Chairman, W. A. GLASS; Vice-Chairman, N. S. BUBBIS; Secretary, F. C. AMSBARY; Trustees, D. L. ERICKSON, L. W. GRAYSON.

Water Resources Div.—Chairman, F. MERRYFIELD; Vice-Chairman, A. D. HENDERSON; Secretary, B. S. GRANT; Trustees, H. C. BARKSDALE, C. H. BECHERT.

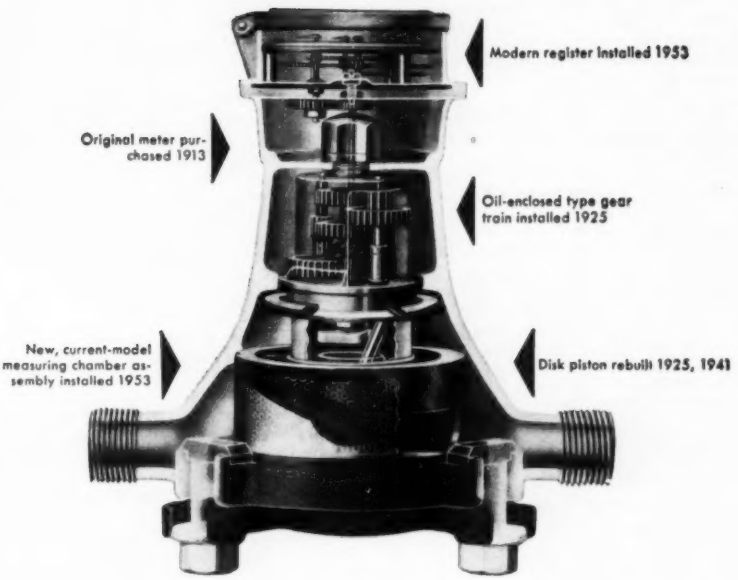
Water Purification Div.—Chairman, W. W. AULTMAN; Vice-Chairman, W. YEGEN; Secretary, H. C. MEDBERY; Trustees, P. E. PALLO, H. H. GERSTEIN, R. L. DERBY.

Transmission and Distribution Div.—Chairman, E. A. SCHMITT; Vice-Chairman, M. K. SOCHA; Secretary, F. E. DOLSON; Trustees, H. W. NIEMEYER, E. S. COLE.

Officers of the Sections

*Section**	*Chairman*	*Vice-Chairman*	*Secretary-Treasurer*	*Past-Chairman*
Alabama-Miss.	W. H. H. Putnam	J. L. Haley	C. W. White	J. L. Mattox
Arizona	W. C. Harford	P. J. Martin Jr.	M. V. Ellis	M. P. Goudy
California	L. E. Goit	H. C. Medbery	J. C. Luthin	J. D. DeCosta
Canadian	C. G. R. Armstrong	C. S. Anderson	A. E. Berry	W. D. Hurst
Chesapeake	G. L. Hall	H. B. Shaw	C. J. Lauter	E. B. Showell
Cuban	G. Bequer H.	R. Granda D.	L. H. Daniel	L. Radelat
Florida	M. R. Boyce	D. W. Jones	H. T. Skaggs	C. H. Helwick
Illinois	H. E. Hudson Jr.	C. W. Klassen	D. W. Johnson	O. Gullans
Indiana	H. F. Zinsmeister	H. J. Draves	G. G. Fassnacht	O. A. Newquist
Iowa	C. W. Hamblin	W. J. Lang	H. V. Pedersen	M. K. Tenny
Kansas	R. S. Millar	O. G. Kuran	H. W. Badley	R. J. Mounsey
Kentucky-Tenn.	R. P. Farrell	J. S. Watkins	J. W. Finney	E. Smith
Michigan	D. Feben	H. O. Self	T. L. Vander Velde	E. D. Barrett
Minnesota	G. J. Schroepfer	H. J. Sowden	L. N. Thompson	N. S. Bubbis
Missouri	J. B. Ramsey	H. E. Newell	W. A. Kramer	W. B. Schworm
Montana	C. Eyer	J. F. Dennis	A. W. Clarkson	A. L. Johnson
Nebraska	C. B. Elliott	B. Gurney	E. B. Meier	H. L. Morris
New England	C. B. Hardy	V. O Valentine	G. G. Bogren	J. E. Hale
New Jersey	C. J. Alfke	W. Spencer	C. B. Tygert	E. A. Bell
New York	T. B. Tyldesley	S. P. Carman	K. Blanchard	J. G. Copley
North Carolina	J. L. Greenlee	W. B. Snow	E. C. Hubbard	H. F. Davis
Ohio	E. F. Leist	G. J. VanDorp	M. E. Druley	C. E. Beatty
Pacific Northwest	E. J. Allen	W. H. Berkeley	O. P. Newman	A. S. G. Musgrave
Pennsylvania	L. D. Matter	J. L. Matthews	L. S. Morgan	L. S. Duckworth
Rocky Mountain	V. A. Vaseen	T. J. Eaton	G. J. Turre	C. M. Bennett
Southeastern	E. C. Matthews	W. C. Bowen	N. M. de Jarnette	T. M. Rogers
Southwest	F. S. Taylor	E. J. Richards	L. A. Jackson	H. Wilkens
Virginia	L. K. McClung	J. M. Pharr	J. P. Kavanagh	B. L. Strother
West Virginia	J J. Dwyer	H. R. Gay	H. K. Gidley	N. Leshkow
Wisconsin	R. E. Cannard	Z. A. Gorder	L. A. Smith	W. F. Leistikow

* For Section's representative on the AWWA Board of Directors, see list on page ii.


Modern register installed 1953
Original meter purchased 1913
Oil-enclosed type gear train installed 1925
New, current-model measuring chamber assembly installed 1953
Disk piston rebuilt 1925, 1941

HOW *OLD* IS THIS METER?

It was built in 1913 . . . but it's almost as new as today.

Its working parts have been completely replaced. Its performance matches every standard of modern metering practice.

The parts used to repair this meter at its last overhaul are identical to those used in the latest Trident meters.

Making modern parts fit "old" meters has been a fixed Neptune policy for over 50 years. It is just one of the extra advantages that make Tridents a better buy . . . both for today and for the years to come.

NEPTUNE METER COMPANY
50 West 50th Street, New York 20, N. Y.

NEPTUNE METERS, LTD.
1430 Lakeshore Road, Toronto 14, Ontario

Branch Offices in Principal American and Canadian Cities

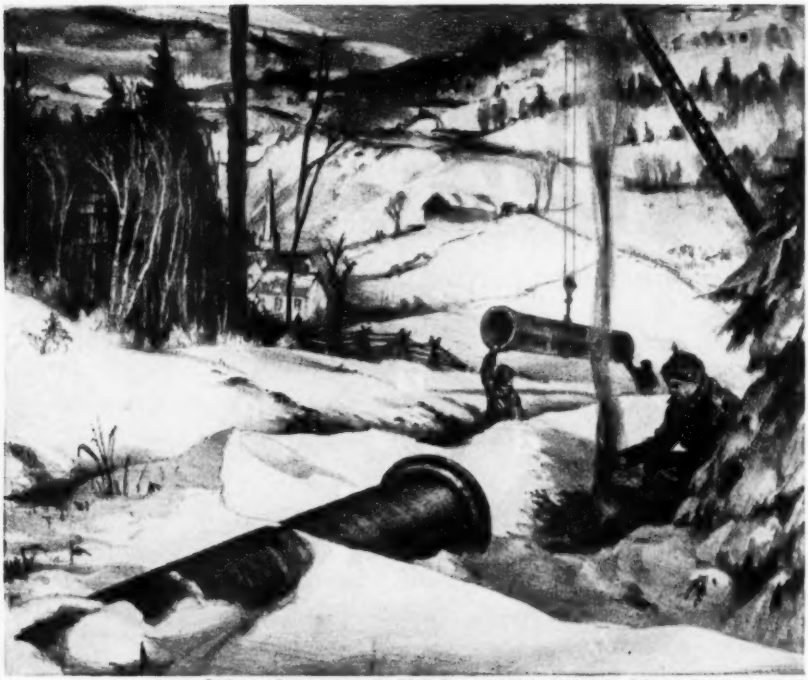
neptune

251

LIST OF ADVERTISERS

	P&R PAGE
A G Chemical Co., Inc.	—
Alabama Pipe Co.	—
Allis-Chalmers	—
American Agricultural Chemical Co.	86
American Brass Co., The	21
American Cast Iron Pipe Co.	—
American Concrete Pressure Pipe Assn.	79
American Cyanamid Co., Industrial Chemicals Div.	72
American Locomotive Co.	91
American Pipe & Construction Co.	37
American Well Works	—
Anthracite Equipment Corp.	—
Armco Drainage & Metal Products, Inc.	31
Atlas Mineral Products Co., The	—
Badger Meter Mfg. Co.	—
Barrett Div., The	89
Belco Industrial Equipment Div.	—
Bethlehem Steel Co.	—
Blockson Chemical Co.	20
Buffalo Meter Co.	80
Builders-Providence, Inc.	28
Calgon, Inc.	17
Carborundum Co., The	—
Carlon Products Corp.	24
Carson, H. Y., Co.	80
Cast Iron Pipe Research Assn., The	14–15
Centriline Corp.	19
Chain Belt Co.	—
Chicago Bridge & Iron Co.	73
Clow, James B., & Sons	43
Cochrane Corp.	11
Crane Co.	83
Darley, W. S., & Co.	82
Darling Valve & Mfg. Co.	18
Davis Mfg. Co.	—
De Laval Steam Turbine Co.	97
Dorr Co., The	Cover 3
Dresser Mfg. Div.	—
Eddy Valve Co.	43
Electro Rust-Proofing Corp.	45
Ellis & Ford Mfg. Co.	—
Everson Mfg. Corp.	—
Filtration Equipment Corp.	—
Fischer & Porter Co.	—
Flexible Sewer-Rod Equipment Co.	93
Ford Meter Box Co., The	51
Foxboro Co.	—
General Chemical Div., Allied Chemical & Dye Corp.	—
Golden-Anderson Valve Specialty Co.	—
Graver Water Conditioning Co.	41
Greenberg's, M., Sons	56
Hagan Corp.	17
Hammond Iron Works	—
Hays Mfg. Co.	39
Hellige, Inc.	—
Hersey Mfg. Co.	13
Hungerford & Terry, Inc.	38
Hydraulic Development Corp.	22
Industrial Chemical Sales Division, West Virginia Pulp & Paper Co.	35
Inertol Co., Inc.	75
Infilco Inc.	49
Iowa Valve Co.	43
Johns-Manville Corp.	8–9
Johnson, Edward E., Inc.	48
James Jones Co.	30
Keasbey & Mattison Co.	27
Kennedy Valve Mfg. Co., The	87
Kitson Valve Div.	29
Klett Mfg. Co.	88
Koppers Co., Inc.	53
Layne & Bowler, Inc.	71
Leadite Co., The	Cover 4
Lock Joint Pipe Co.	3
M & H Valve & Fittings Co.	95
McWane Cast Iron Pipe Co.	85
Mueller Co.	23
National Cast Iron Pipe	43
National Water Main Cleaning Co.	81
Neptune Meter Co.	5
Northern Gravel Co.	66
Northrop & Co., Inc.	44
Omega Machine Co. (Div., Builders Iron Fdry.)	—
Ozone Processes Div.	—
Pacific States Cast Iron Pipe Co.	85
Pekrul Gate Div., (Morse Bros. Machinery Co.)	—
Permutit Co.	26
Phelps Dodge Refining Corp.	—
Philadelphia Gear Works, Inc.	46
Pipelife, Inc.	—
Pittsburgh-Des Moines Steel Co.	—
Pittsburgh Equitable Meter Div. (Rockwell Mfg. Co.)	98
Pollard, Jos. G., Co., Inc.	42
Portland Cement Assn.	69
Proportioners, Inc.	—
Reilly Tar & Chemical Corp.	—
Rensselaer Valve Co.	25
Roberts Filter Mfg. Co.	67
Rockwell Mfg. Co.	98
Rohm & Haas Co.	—
Ross Valve Mfg. Co.	65
Simplex Valve & Meter Co.	16
Skinner, M. B., Co.	84
Smith, A. P., Mfg. Co., The	63
Smith-Blair, Inc.	—
Solvay Process Div., Allied Chemical & Dye Corp.	—
Southern Pipe & Casing Co.	—
Sparling Meter Co., Inc.	68
Stuart Corp.	84
Tennessee Corp.	82
U.S. Pipe & Foundry Co.	7
Universal Concrete Pipe Co.	64
Walker Process Equipment, Inc.	—
Wallace & Tiernan Co., Inc.	32–77
Well Machinery & Supply Co.	55
Welsbach Corp.	29
Wood, R. D., Co.	Cover 2
Worthington-Gamon Meter Div.	47

Directory of Professional Services—pp. *57-61 P&R*



Lithographed on stone for U. S. Pipe and Foundry Co. by John A. Noble, A. N. A.

WINTER OR SUMMER, in the hills or on the flats, make no difference to cast iron pipe. Whether it is used for a water supply line, a gas feeder main or a pressure sewer, cast iron pipe has a rich history of highly satisfactory performance behind it for each type of service.

U. S. pipe centrifugally cast in metal molds up to 24-inch, pit cast pipe in the larger sizes and fittings are made in accordance with Federal, American Standard and American Water Works Association specifications wheresoever they apply.

With our production distributed in five strategically located plants, we are in an excellent position to meet your requirements.

United States Pipe and Foundry Co., General Office, 3300 First Ave., N., Birmingham 2, Ala. • Plants and Sales Offices Throughout the U. S. A.

U.S.
cast iron
PIPE

NEW Transite®
2
2
1
3
This cut-away* section shows:
1. Pipe ends automatically separated for flexibility and expansion.
2. Rubber rings compressed for water-tightness.
3. Coupling and pipe made of long-lived corrosion-resistant asbestos-cement Transite.
INSTALLATION OF TRANSITE RING-TITE COUPLING IS SURE, SIMPLE, EASY
A. Rubber rings in groove before assembly
B. Rubber rings compressed after assembly

*NOTE: In the large photograph above, a portion of the Ring-Tite Coupling has been removed to show its design. One rubber ring has been cut to illustrate how it is compressed between pipe and coupling.

Johns-Manville

RING-TITE® Coupling

provides greater economy in pipeline installation ... maximum performance in service

- **Simplifies Transite Pressure Pipe assembly**
- **Reduces installation time**
- **Helps assure tight, flexible joints**

BECAUSE of its unique design, the new Johns-Manville Ring-Tite Coupling provides many money-saving advantages. For example, no complicated equipment is required for line assembly. With tight, flexible Ring-Tite joints easily obtained, the contractor can get in and get out quickly with a substantial saving of time and money.

Ring-Tite Coupling installations can be made under adverse weather, temperature, or terrain conditions. Loose sand, slippery clay, mud and ice do not interrupt pipe assembly nor affect the performance of the completed assembly. Transite Pressure Pipe and Ring-Tite Couplings can be assembled in wet trenches.

Rings automatically positioned and locked in place

Pipes need only rough aligning. The coupling does the rest automatically . . . centers, aligns and adjusts for expansion. Rings are automatically pre-positioned by simply "popping" them into prepared grooves . . . and when the pipe is being pulled, the sliding motion of the rings squeegees all loose foreign material from the end of the pipe.

Each Ring-Tite Coupling is automatically stopped in exactly the correct sealing position to assure maximum water tightness and joint flexibility . . . to permit conformance to curves . . . to withstand shock and vibration . . . to relieve line stresses.

As a long-term investment, Transite Pressure Pipe effects outstanding performance and economies in your water supply and distribution expansion programs. Now the Ring-Tite Coupling brings you equally substantial *installation* economies—*immediate* savings!

For further information, write Johns-Manville, Box 60, New York 16, N.Y.

JM

Here on this 12" New England installation of the Ring-Tite Coupling, the contractor's bid was based on installing 400 feet per working day for the job conditions prevailing. Actual laying time averaged over 700 ft. per day!

TRANSITE PRESSURE PIPE

Coming Meetings

AWWA SECTIONS

Nov. 4–6—Virginia Section at Roanoke Hotel, Roanoke. Secretary, J. P. Kavanagh, Dist. Mgr., Wallace & Tiernan Co., Inc., 915 Colonial-American Bank Bldg., Roanoke 11.

Nov. 9–11—North Carolina Section at Hotel Sheraton, High Point. Secretary, E. C. Hubbard, Exec. Secy., State Stream Sanitation Com., Box 2091, Raleigh.

Dec. 3–5—Cuban Section at Havana. Secretary, L. H. Daniel, Baratillo 9, Havana.

Jan. 19, 1954—New York Section Winter Luncheon Meeting, at Commodore Hotel, New York. Secretary, Kimball Blanchard, Rm. 1922, 50 W. 50 St., New York 20, N.Y.

Feb. 10–12—Indiana Section at Lincoln Hotel, Indianapolis. Secretary, G. G. Fassnacht, State Dept. of Health, 1330 W. Michigan St., Indianapolis 7, Ind.

Mar. 17–19—Illinois Section at LaSalle Hotel, Chicago. Secretary, Dewey W. Johnson, Research Engr., Cast Iron Pipe Research Assn., 122 S. Michigan Ave., Chicago 3, Ill.

Mar. 18—New England Section at Hotel Statler, Boston. Secretary, George G. Bogren, Partner, Weston & Sampson, 14 Beacon St., Boston 8, Mass.

Apr. 7–9—Kansas Section at Broadview Hotel, Emporia. Secretary, Harry W. Badley, Repr., Neptune Meter Co., 119 W. Cloud, Salina, Kan.

Apr. 12–14—Canadian Section at Royal York Hotel, Toronto. Secretary, A. E. Berry, Director, Ontario Dept. of Health, Parliament Bldgs., Toronto 8, Ont.

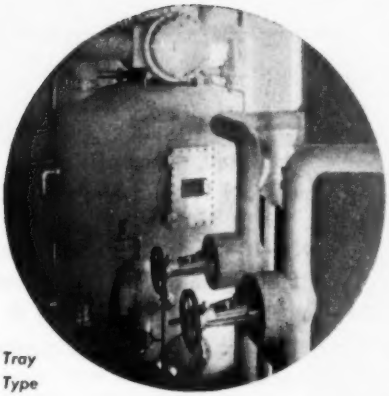
Apr. 22–23—Nebraska Section at Cornhusker Hotel, Lincoln. Secretary, E. Bruce Meier, Asst. Prof. of Civil Engineering, Univ. of Nebraska, Lincoln, Neb.

AWWA ANNUAL CONFERENCE

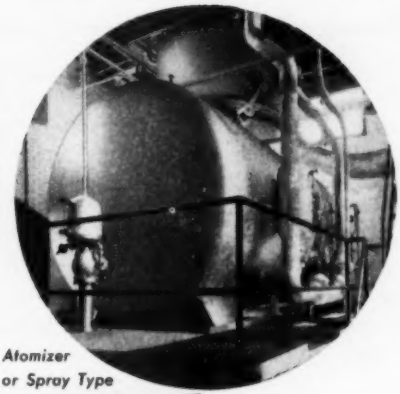
Seattle, Wash. **May 23-28, 1954**

All reservations will be cleared through the AWWA office. The hotels have agreed to accept no reservations for the 1954 Conference except as they are requested on the standard form, through the AWWA.

(*Continued on page 12*)



Tray Type



Atomizer or Spray Type

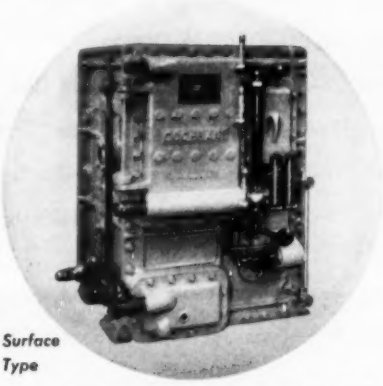
DEAERATORS FOR ALL REQUIREMENTS

HAVE YOU PROBLEMS OF: CORROSION? FEED WATER HEATING? DEAERATION?

Call Cochrane. Whether your plant is large or small, the *unbiased* recommendations of Cochrane Engineers will assure the correct selection of equipment for your particular operating conditions. As specialists in the field of Deaeration, Cochrane originated the jet tray and atomizing principles and designs and manufactures all types of Deaerating equipment—Tray, Jet Tray, Atomizer or Spray, and Surface—in all sizes, all materials.

Over 90 years of specialized experience in water conditioning are at your service when you call a Cochrane Engineer. Write for the address of our office nearest you. We'll be happy to discuss your requirements without obligation.

Jet Tray Type



Surface Type

cochrane

corp. 3124 N. 17th Street, Philadelphia 32, Pa.

offices in 30 principal cities

In Canada: Canadian General Electric Co., Ltd., Toronto
In Mexico: Babcock & Wilcox de Mexico, S.A., Mexico City
In Europe: Recuperation Thermique & Epuration, Paris
In Cuba: Laurence E. Daniel, Inc., Havana
In South America: Servicios Electricos, C. A. (S.E.C.A.) Caracas, Venezuela
In Puerto Rico: F. A. Ortiz & Co., San Juan 5

Coming Meetings

(Continued from page 10)

Apr. 22–23—New York Section at Woodruff Hotel, Watertown. Secretary, Kimball Blanchard, Rm. 1922, 50 W. 50 St., New York 20, N.Y.

Apr. 22–24—Arizona Section in Tucson. Secretary, M. V. Ellis, Supervisor, Sewage Treatment Plant, Phoenix, Ariz.

Apr. 23–24—Montana Section at Baxter Hotel, Bozeman. Secretary, A. W. Clarkson, Acting Chief, Water Section, Div. of Environmental Sanitation, State Board of Health, Helena, Mont.

June 16–18—Pennsylvania Section at Americus Hotel, Allentown. Secretary, L. S. Morgan, Div. Engr., State Dept. of Health, Greensburg, Pa.

FALL SECTION MEETINGS

Sept. 8–10—New York, in Montauk, L.I.

Sept. 15–17—Michigan, in Muskegon

Sept. 22–24—Ohio, in Dayton

Sept. 28–30—Wisconsin, in Green Bay

Oct. 17–20—Southwest, in El Paso, Tex.

Oct. 26–29—California, in Long Beach

Oct. 27–29—Chesapeake, in Baltimore (Tentative)

Nov. 3–5—Virginia, in Richmond

Nov. 4–6—New Jersey, in Atlantic City

OTHER ORGANIZATIONS

Nov. 8–11—National Inst. of Governmental Purchasing at Netherlands Plaza, Cincinnati, Ohio. Details from Albert H. Hall, Exec. Director, 730 Jackson Pl., N.W., Washington 6, D.C.

Nov. 9–13—American Public Health Assn., Hotels Statler and New Yorker, New York, N.Y. Details from R. M. Atwater, Exec. Secy., 1790 Broadway, New York, N.Y.

Dec. 1–4—Corrosion Control Short Course at Univ. of Oklahoma, Norman. Details from John B. Freeman, Director, Dept. of Short Courses & Conferences, Univ. of Oklahoma, Norman, Okla.

1954 MEETINGS

May 4–6—American Public Power Assn., in Chicago

May 4–7—American Welding Society, in Buffalo, N.Y.

June 13–18—American Society for Testing Materials, in Chicago

Sept. 13–15—New England Water Works Assn., in Dixville Notch, N.H.

Oct. 11–14—Federation of Sewage & Industrial Wastes Assn., in Cincinnati.

Oct. 11–15 (tentative)—American Public Health Assn., in Buffalo

Oct. 17–20—American Society of Civil Engineers, in New York City

Oct. 19–22—Pennsylvania Water Works Assn., in Atlantic City, N.J.

Nov. 28–Dec. 3—American Society of Mechanical Engineers, in New York.

There is NO SUBSTITUTE *for a*

HERSEY COMPOUND METER

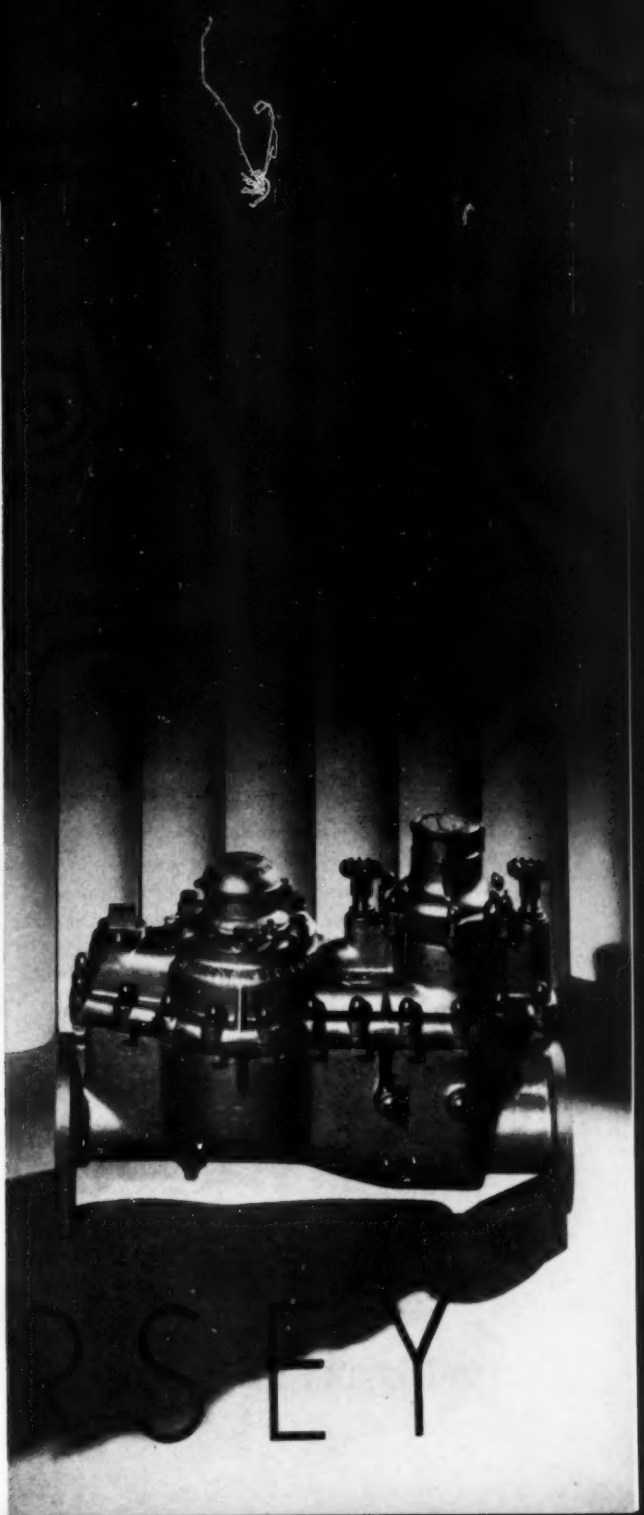
Water Works Engineers who have made very careful tests always arrive at the same results; namely, that HERSEY Compound Meters have never been equaled for accurate registration of all rates of flow.

Self-contained Bronze Case up to 6"

HERSEY MANUFACTURING COMPANY

SOUTH BOSTON, MASS.

BRANCH OFFICES: NEW YORK — PORTLAND, ORE. — PHILADELPHIA — ATLANTA — DALLAS — CHICAGO — SAN FRANCISCO — LOS ANGELES



Research and Development bring you this finer-than-ever pipe

You can't better a product like cast iron pressure pipe—with its unparalleled record of long life, economy and efficiency—by waving a wand. Yet the story of how the best product in its field has been made *still better* can be told in a paragraph.

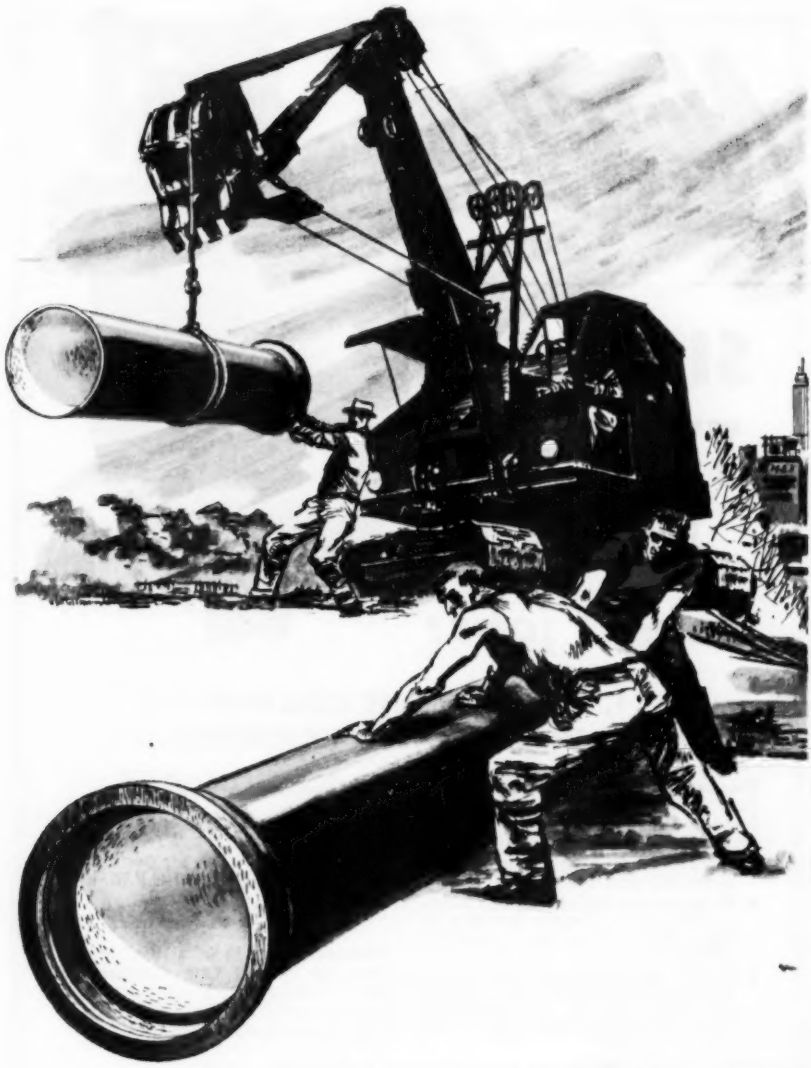
***Modernized* cast iron pipe is a result of the sum total of recent product and process improvements attained by research and development.**

It is centrifugally-cast and, when needed, centrifugally cement-lined. It is tougher, stronger, more uniform in quality. It is tuberculation-proof with sustained carrying capacity for the life of the pipe.

If you want the most efficient and economical pipe ever made for water distribution, your new mains will be laid with *modernized* cast iron pipe with either mechanical or bell-and-spigot joints. Cast Iron Pipe Research Association, Thos. F. Wolfe, Managing Director, 122 So. Michigan Ave., Chicago 3.

This cast iron water main, uncovered for inspection, is in good condition after over a century of service in Detroit, Mich.—one of more than 45 cities with century-old water or gas mains in service.

Modernized **cast iron**



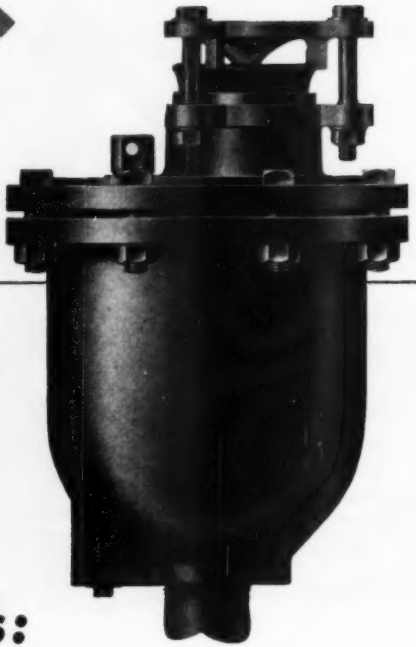
CAST IRON

The Q-Check stencilled on pipe is the Registered Service Mark of the Cast Iron Pipe Research Association.

pipe

for Modern Waterworks Operation

New!



SIMPLEX TYPE AV VALVE

does 2 jobs:

1. STOPS PIPELINE COLLAPSE!
2. ENDS AIR ACCUMULATIONS!

Simplex Type AV Valve is more than just a compact combination air release and air inlet valve. For it performs three separate functions:

- Admits air to break vacuums . . . prevents pipeline collapse.
- Releases air accumulations automatically to prevent binding at high points . . . increase pumping efficiency.
- Vents large quantities of air when filling the system . . . saves you from buying an oversized valve for this limited use.

High Discharge Capacity!

For this small, rugged unit—discharge capacities range from nearly 900 cubic feet of free air per minute at 10 psig to over 2200 C.F.M. at 50 psig.

Check These Features!

Compact! Only 11⅝" x 16¼" in size. Easy to install! One standard 2" pipe connection. Positive-acting, non-corrodible float. Hydrostatically tested to 300 psig.

Write for Free Technical Bulletin No. 1203

SIMPLEX VALVE & METER COMPANY
6784 UPLAND STREET, PHILADELPHIA 42, PA.

SIMPLEX®

VALVE AND METER COMPANY

ANNOUNCEMENT

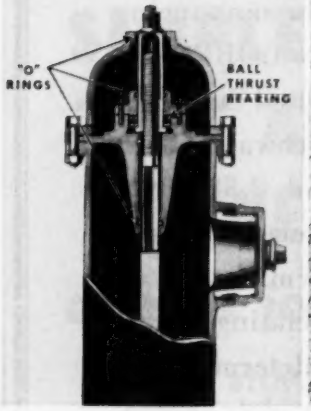
Chemische Fabrik Uetikon of Uetikon, Switzerland, takes pleasure in announcing the appointment of HAGAN CORPORATION as its agent in the United States for the licensing of Uetikon's Schwarzenbach patents Nos. 2,583,890 and 2,583,891. These patents cover revolutionary methods for the quantitative determination of metallic ions with organic chelating agents. Of particular interest is the determination of hardness in water, already widely known. Additional applications of these methods, developed by Dr. Gerold Schwarzenbach of the University of Zurich, are constantly being made.

Inquiries on all matters pertaining to licensing should be directed to

HAGAN CORPORATION

P.O. Box 1346
Pittsburgh 30, Pennsylvania

TRADE DARLING MARK



A. W. Grathwol, manager of the Sandusky, Ohio, Water Distribution Department, checking static water pressure on a newly installed Darling B-50-B hydrant.

Word is getting around about DARLING'S NEW B-50-B FIRE HYDRANT

WATER distribution men like A. W. Grathwol of the Sandusky, Ohio, Water Distribution Department, are spreading the good news about the new patented Darling B-50-B fire hydrant. It rates as the most important fire hydrant advance in 50 years.

Here are reasons why . . .

1. The "O" ring seals eliminate need for a stuffing box. Darling's B-50-B is a packless, *dry-top* hydrant that saves service time and trouble. It does away with bothersome packing gland adjustment and maintenance, assures constant lubrication of the operating threads *and prevents water from reaching the operating threads.*

2. The Darling B-50-B is a *ball-bearing* operated hydrant. Opening and closing takes less than half the usual wrench torque.

And you also get another long-time advantage of Darling hydrants . . . all inside working parts, including the main valve seat and drain valve seats, can be removed through the top *by one man* for on-the-spot inspection and maintenance. Write for Bulletin No. 5007 before you decide on any hydrant. Address . . .

DARLING VALVE & MANUFACTURING CO.

Williamsport 23, Pa.

Manufactured in Canada by The Canada Valve & Hydrant Co., Ltd., Brantford 7, Ontario

water
is important to everybody...

The Miss at this fountain of youth would be mighty disappointed if low water pressure were suddenly to deprive her of a drink—and so would millions of others who take water pressure for granted. One of the best, and least expensive ways to assure the constant flow of water is through Centrilining.

The Centriline process thoroughly cleans and centrifugally applies cement-mortar to the interior of pipe lines in place—prevents corrosion, tuberculation and leakage; minimizes interruption of line operation and street traffic. For an effective, economical means of increasing flow capacity, look to Centriline.

Write for free booklet today.

CEMENT-MORTAR LININGS FOR PIPES IN PLACE

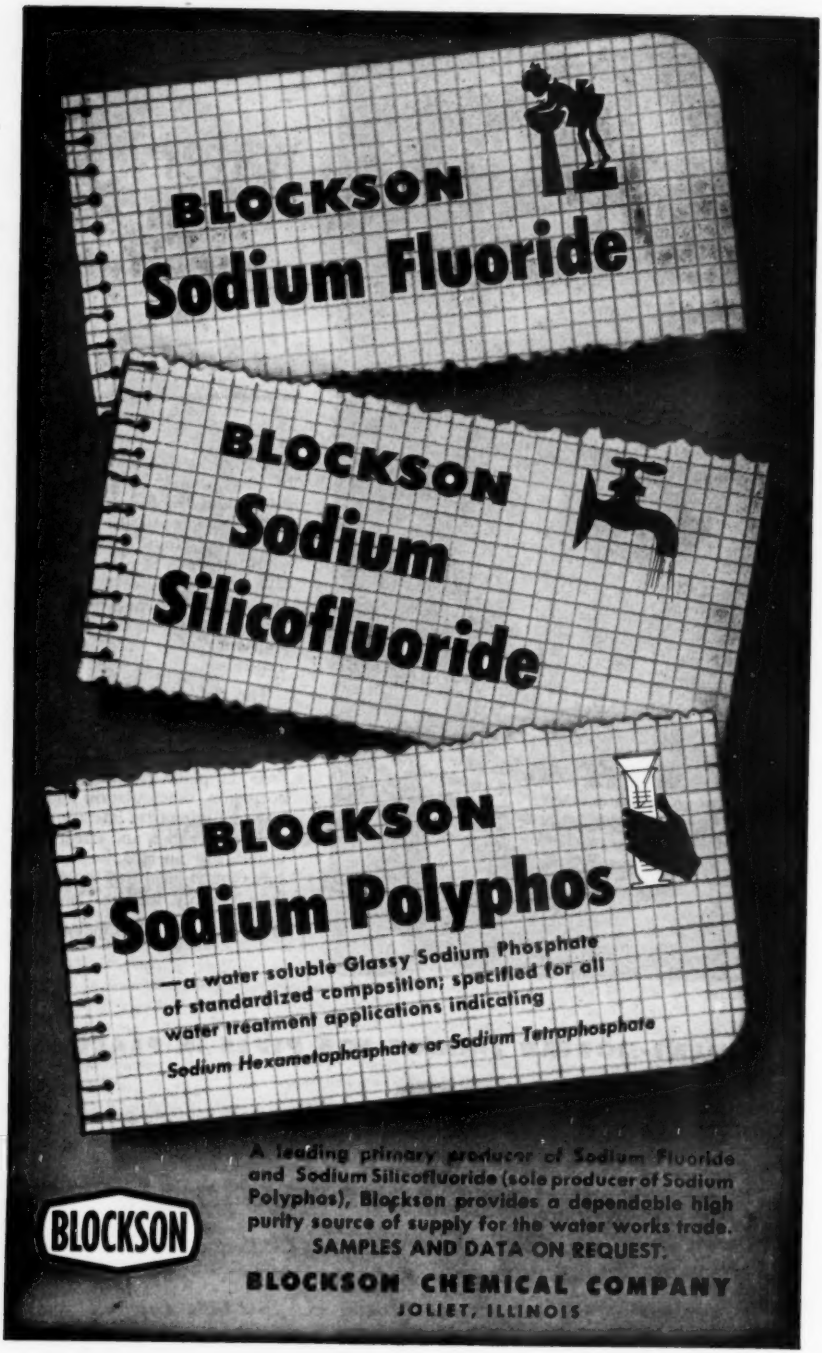
3,000,090 FEET OF EXPERIENCE

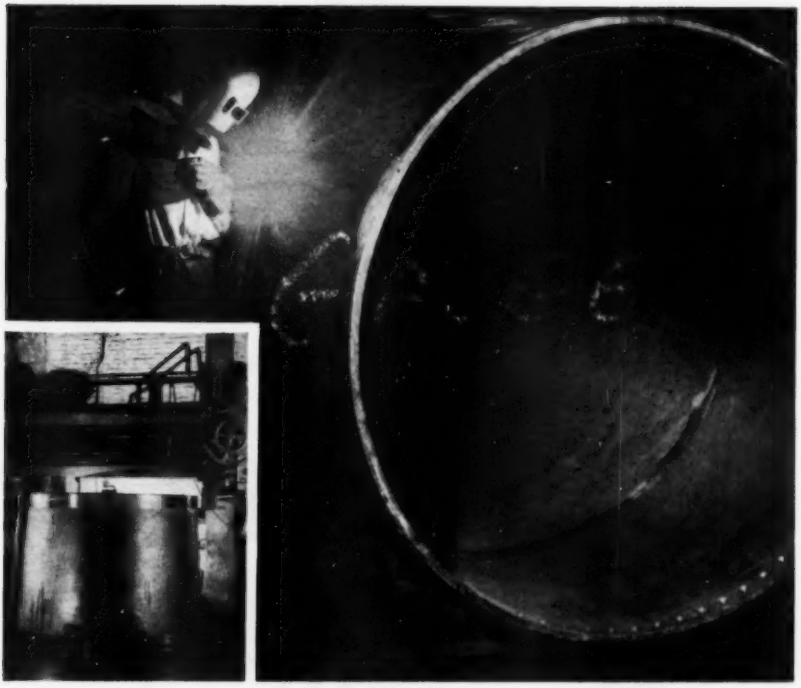
CENTRILINE CORPORATION

A subsidiary of Raymond Concrete Pile Co.

140 CEDAR STREET, NEW YORK 6, N. Y.

Branch Offices in Principal Cities of United States and Latin America


BLOCKSON
Sodium Fluoride
BLOCKSON
Sodium
Silicofluoride
BLOCKSON
Sodium Polyphos
—a water soluble Glassy Sodium Phosphate of standardized composition; specified for all water treatment applications indicating
Sodium Hexametaphosphate or Sodium Tetraphosphate
A leading primary producer of Sodium Fluoride and Sodium Silicofluoride (sole producer of Sodium Polyphos), Blockson provides a dependable high purity source of supply for the water works trade.
SAMPLES AND DATA ON REQUEST.
BLOCKSON
BLOCKSON CHEMICAL COMPANY
JOLIET, ILLINOIS



TAPERED small-end Everdur section, before being welded to large-end tapered section, is machined to fit throat at C. H. Wheeler Mfg. Co.

THROAT OR INTAKE END of the 2-section, 16-foot-long Venturi outlet cone. This throat is made by roll forming ⅝-inch Everdur-1010 plate at The Daniel Russell Boiler Works, Boston, Massachusetts. Here a seam is being welded by the Aircomatic® process using Everdur-1010 Welding Rod.

This Everdur Venturi Tube Meters 350,000 gpm Through New York's Neversink Tunnel

Metering that much water flowing through the new Neversink Tunnel of New York's Delaware Water Supply System at 235 psi static pressure at cone required an accurately fabricated, strong, corrosion-resistant Venturi outlet cone approximately 16-feet long with an 8-foot diameter tapering to 5 feet, 5 inches at the throat.

Such equipment, buried in the tunnel, must not fail—and Builders-Providence, Inc., the supplier, had to design to exacting specifications. Costs were also a factor. This huge cone was, therefore, designed for welded fabrication of ⅝-inch-thick Everdur*-1010 (ANACONDA Copper-Silicon Alloy) plate.

Depending on the alloy, you can work Everdur hot or cold, and easily form, forge, weld and machine it. Everdur is available in plates, sheets, rods, tubes, electrical conduit and casting ingots.

Our Technical Department's services are always yours for selecting the best and most practical material for your equipment. *The American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.*

*Reg. U. S. Pat. Off. 53142A

EVERDUR
ANACONDA®
COPPER-SILICON ALLOYS
STRONG • WELDABLE • WORKABLE
CORROSION-RESISTANT

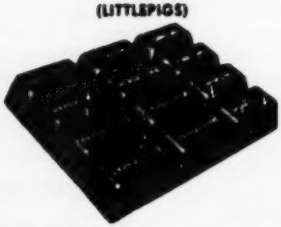
HYDRO-TITE and FIBREX

THE DEPENDABLE JOINT COMPOUND THE BACTERIA-FREE PACKING

ring the bell every time with a perfect joint—

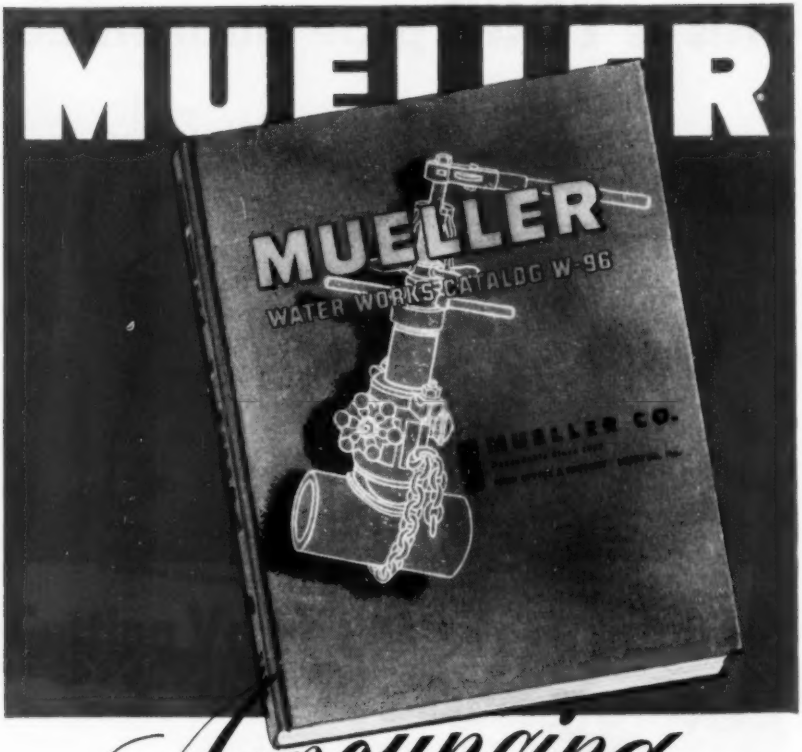
HYDRO-TITE (POWDER)

HYDRO-TITE (LITTLEPIGS)



FIBREX (REELS)

HYDRAULIC DEVELOPMENT CORPORATION



Announcing

the new Mueller Water Works Catalog

A new Mueller Water Works Catalog will be sent to you during the month of November. If you are in need of additional copies, drop us a line or contact your Mueller Representative.

Write Dept. A-36

MUELLER CO.

Dependable Since 1857

MAIN OFFICE & FACTORY DECATUR, ILLINOIS

This is YOUR pipe guarantee!

CARLON CP

Guarantee

Carlon pipe is guaranteed to be free from defects in material and workmanship and to perform satisfactorily when stocked and handled in accordance with Carlon's recommended specifications.

All Carlon pipe is specifically guaranteed forever against rot, rust and electrolytic corrosion, and "EF" pipe is further guaranteed to be manufactured from pure, non-toxic materials processed for improved performance by Carlon.

Carlon's liability is limited to replacement of, or credit for, defective material when such material is brought to Carlon's attention and defect demonstrated to an accredited Carlon representative within a reasonable period of time from the date of sale.

CARLON... the first real pipe that is plastic

CARLON plastic pipe will perform to your complete satisfaction . . . otherwise, Carlon will replace the pipe or give you credit. Only Carlon gives you this unconditional guarantee of quality and performance. No other plastic pipe manufacturer can equal the Carlon guarantee . . . it's genuine . . . backed by Carlon's years of service as the world's leading producer of plastic pipe. For your protection, every foot of Carlon is factory-tested at greater than working pressures for more than 8 hours.

Buy the Pipe with the Stripe!

CARLON CP

CARLON PRODUCTS CORPORATION
10300 MEECH AVE. ★ CLEVELAND 5, OHIO

CARLON plastic pipe is produced in Ohio, Colorado, N. Carolina, Oregon, Texas and Ontario ★ Export: H. E. Botzow, New York City

1572-CP

Cutting Valve Costs for a lifetime

This interesting assembly consists of a 20 inch Rensselaer valve with reducing and increasing sections for installation in a 30 inch pipe line. The integral type gear case is designed for the working pressure of the valve and is packed with oil for lifetime service.

There is no need for a concrete vault for valves equipped with integral type gear cases. Just install valve boxes, shovel back the dirt and forget it, for this is the Rensselaer double disc valve with the well known wedge action. On closing, when the gates reach a position opposite their seats, the powerful wedging action presses them squarely and firmly against their seats. It is impossible to damage the stem threads or throw the stem out of alignment, and the gates open and close easily.

The valve you buy today should serve faithfully for many years. Why not provide maximum insurance against future maintenance costs by putting in Rensselaer valves in the first place?

Rensselaer VALVE COMPANY, TROY, N. Y.

GATE VALVES • FIRE HYDRANTS • SQUARE BOTTOM VALVES • CHECK VALVES • AIR RELEASE VALVES

SALES REPRESENTATIVES IN PRINCIPAL CITIES

102

How Hallandale, Florida, got Soft, Clear Water

PROBLEM

Well water with hardness of over 240 ppm--mostly bicarbonate--and objectionable organic color. Softening and color removal definitely required. Water Conditioning equipment to be economical in serving today's 5,000 population ... to retain this economy in providing 1980's population with 2,000,000 gpd.

SOLUTION

Briley, Wild & Associates, Consulting Engineers, Daytona Beach, Fla., studied latest methods & equipment. Selected lime-alum method. Specified modern type unit for highly efficient reaction between minerals in water and lime-alum. Installed--Permutit Vertical Precipitator. Upward filtration through suspended sludge blanket gives intimate chemical contact, makes for operating economy.

RESULTS

Softened, clear water. Permutit Precipitator removes color and reduces hardness to desired level. Last traces of turbidity are removed by filtration through gravity filters.

For full information write to THE PERMUTIT COMPANY, DEPT. JA-11, 330 WEST 42nd STREET, NEW YORK 36, N. Y., or to Permutit Company of Canada, Ltd., 6975 Jeanne Mance Street, Montreal.

WATER CONDITIONING HEADQUARTERS FOR 40 YEARS

PERMUTIT®

into the rocky soil
of New England
goes
"Century"®
asbestos-cement pipe

Because "Century" pipe is so easy to handle and assemble, the laying crew works right on the heels of the "digger".

This is typical of certain of the hard, rock-filled soil around South Hadley Falls, Mass., in which "Century" pipe was laid. Engineers: Tighe & Bond, Holyoke, Mass.; Contractor: Ted Ondrick, Chicopee Falls, Mass.

One of the latest installations of "Century" asbestos-cement pressure pipe is at South Hadley Falls, Mass. As with other "Century" installations in rocky New England soil—"the digging was tough, but the laying was easy."

Quick and easy laying is just one of the important advantages of "Century" pipe and its Simplex Couplings. Being made from asbestos fiber and portland cement, it cannot rust or tuberculate. It will carry its rated flow at normal pressure for years and years, keeping pumping costs low.

This durable, economical pipe has served American communities for years, and its use increases each succeeding year. Before *your* community contracts for its next water main, you might like to know more about "Century" asbestos-cement pipe. We shall gladly send you complete information.

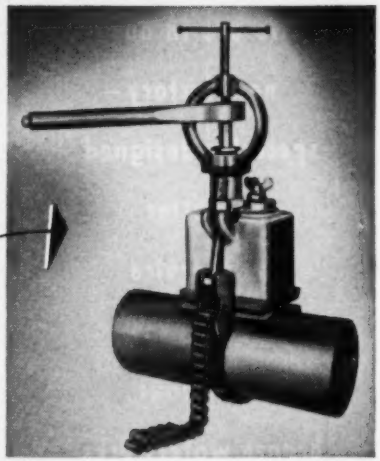
Free Booklet "Mains Without Maintenance" gives valuable data, specifications, and reference material for anyone interested in water main pipes. Write for your copy now.

Nature made asbestos . . .
Keasbey & Mattison has made it serve mankind since 1873

KEASBEY & MATTISON
COMPANY • AMBLER • PENNSYLVANIA

BUILDERS
BUILDERS-PROVIDENCE
For the latest in water works equipment . . .
. . . keep BUILDERS in the picture!
FOR METERING MAIN LINES
Venturi Tubes and Nozzles • Orifice Meters • Propelaflo Meters • Pneumatic, Electric and Mechanical Instruments
FOR CONTROLLING FLOW
Venturi Rate Controllers – Hydraulically-Operated and Direct-Acting
FOR CHLORINATION
Visible Flow Chlorinizers
FOR WATER FILTRATION
Pneumatic and Mechanical Filter Gauges (Loss of Head and Rate of Flow) • Liquid Level Gauges • Wheeler Filter Bottoms • Filter Operating Tables
FOR PACING CHEMICAL FEEDERS
Chronoflo Transmitters and Receivers (electrically operated) • Pneumatic Transmitters and Receivers
☆ ☆ ☆
For complete information and illustrated Bulletins describing Builders Water Works Equipment, address Builders-Providence, Inc. (Division of B-I-F Industries), 36 Harris Ave., Providence 1, R. I.
B-I-F
B-I-F INDUSTRIES
A CENTURY OF QUALITY
1853
BUILDERS

It's new... and better!



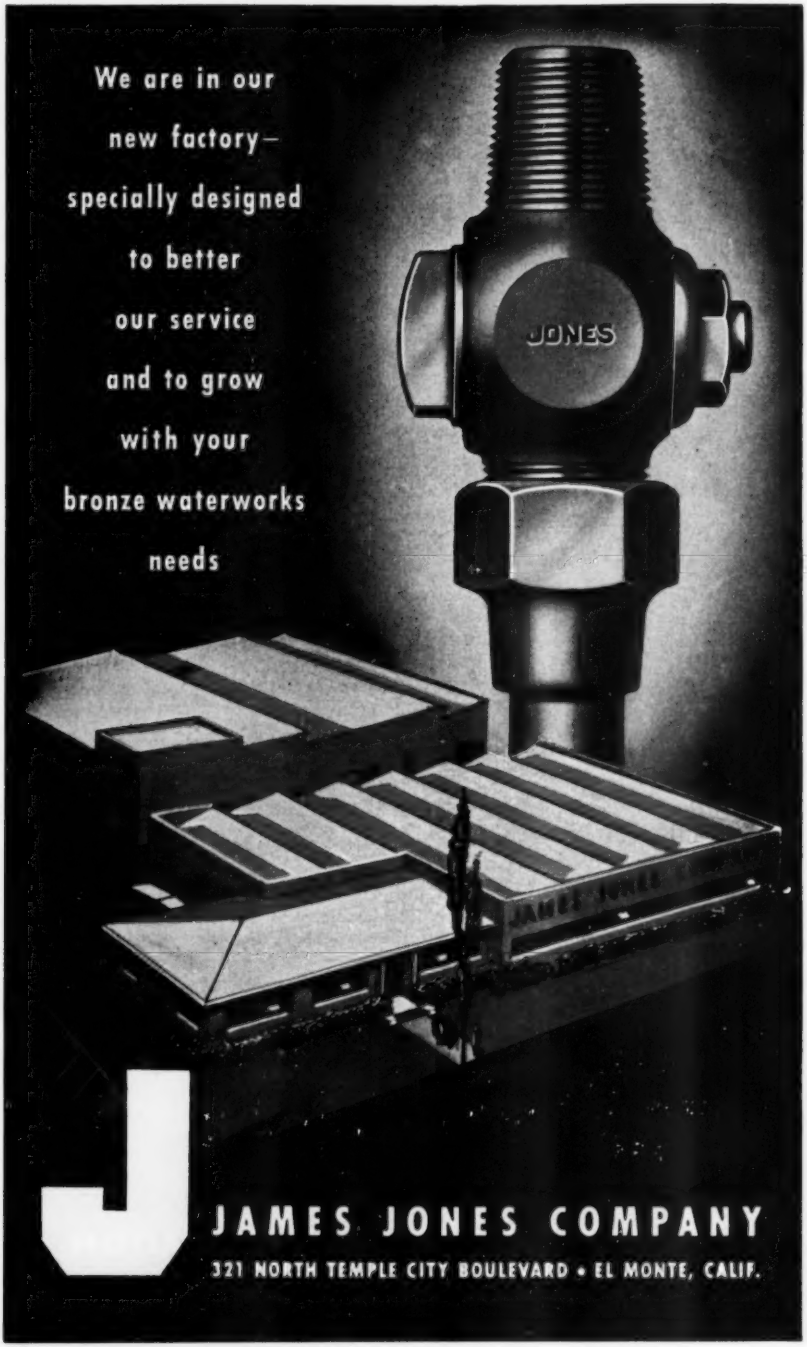
the
WELSBACH
Kitson
CORPORATION TAPPING MACHINE

For installing corporation stops under pressure, this is the safest, surest, most easily-handled and, without sacrifice of inherent strength, the lightest corporation tapping machine ever made. It is so compact that it is ideal for making taps where space is limited.

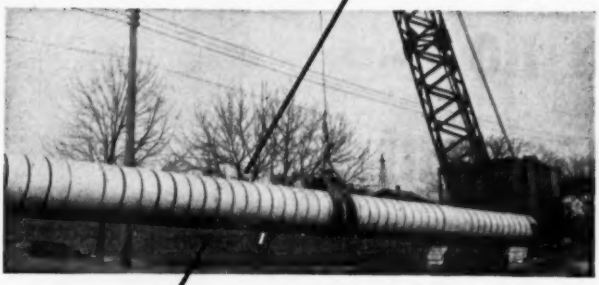
It is the new Welsbach-*Kitson* Corporation Tapping Machine—an improved model of the popular Smith-Shelly Tapping Machine, equipped now with a flat chain and adaptor that provides positive non-slip pipe-gripping action . . . which makes it an even better machine than before. And in keeping with the simplicity of operation of this popular machine, the new adaptor, which gives *positive* pipe-gripping action, is easy to set and helps speed the operation.

with the new
POSITIVE, NON-SLIP
PIPE-GRIPPING ACTION!

THE WELSBACH CORPORATION
Kitson Valve Division
1500 Walnut Street, Philadelphia 2, Pa.


We are in our
new factory—
specially designed
to better
our service
and to grow
with your
bronze waterworks
needs
JONES
JAMES JONES COMPANY
321 NORTH TEMPLE CITY BOULEVARD • EL MONTE, CALIF.

Joints are few



and far between here

They can be 50 feet apart, to be exact. That's because Armco Welded Steel Pipe is usually supplied in long, 50-foot lengths that simplify handling and hauling. And with fewer joints to make, installation costs drop and the job hurries along.

With the wide range of diameters (6 to 36 inches) and wall thicknesses (9/64- to 1/2-inch) it is easy to meet capacity and strength requirements for your supply line, force main or water works piping.

Armco Pipe also offers a combination of ample strength with ductility. This means that it will resist pressure surges and absorb the impact of heavy loads without damage. Outside coatings are supplied to meet A.W.W.A. specifications; a spun enamel lining will prevent tuberculation.

Write us for more details on time- and money-saving Armco Welded Steel Pipe. Armco Drainage & Metal Products, Inc., Welded Pipe Sales Division, 2843 Curtis Street, Middletown, Ohio. Subsidiary of Armco Steel Corporation. In Canada: write Guelph, Ontario.

Armco Welded Steel Pipe

ARMCO

Meets A.W.W.A. Specifications

pedigree is no accident...

Just as a show-dog's winning pedigree is no accident, neither is the pedigree of a Wallace & Tiernan Chlorinator. Both are distinctive and reflect the result of years of selection, training and experience.

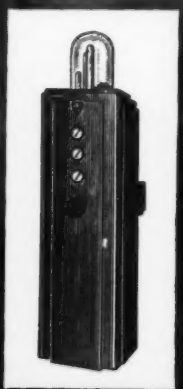
Selection, in the sense of progressive, laboratory-tested improvements in design and construction . . . Improvements which increase the value of dependability "inbred" in W&T Equipment for forty years.

Training, in the sense of a nation-wide staff of Chlorination Specialists, equipped to give prompt service and installation advice on all W&T Equipment.

Experience, in the sense of the many thousands of W&T Chlorinator installations, now meeting the particular daily chlorination requirements of communities all over the world.

The pedigree of a W&T Chlorinator is an open book. Why not write for a free introductory chapter today?

S-83



WALLACE & TIERNAN

NEWARK 1, NEW JERSEY

Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 45 • NOVEMBER 1953 • NO. 11

Control of Water Pressure in Suburban Distribution Lines

By J. S. Williams

A paper presented on May 13, 1953, at the Annual Conference, Grand Rapids, Mich., by J. S. Williams, Vice-Pres., Automatic Control Co., St. Paul, Minn.

CONTROLLING water pressure on suburban distribution lines is a very broad subject and encompasses many problems. This paper is concerned primarily with maintaining such pressure without storage.

Generally, the suburban or peripheral distribution area requires booster pumping. The original or primary system, having surpassed its intended design growth factor, is inadequate to supply the newer area throughout the 24-hr period. For many reasons it is more practical to install high-service, booster pumping stations than to redesign the primary system completely in order to incorporate the new area. The new service is literally an independent system, superimposed upon the old, which provides a broad range of flows to meet the varying demand at adequate heads. Such booster stations may consist of one or more pumps, depending upon the requirements of the specific installation.

There are three basic methods by which water distribution at adequate pressure can be accomplished. In the order of frequency of usage, these methods are: [1] elevated storage; [2] hydropneumatic tanks; and [3] what is known as the closed system, or direct pumpage with no storage.

In the most common application, an elevated tank is included in the design of the new distribution system. Quite naturally this system will be automatically controlled, because in this day and age it is no more conceivable to operate pumps manually than it is to fire a furnace by hand or light side-arm heaters with matches. For ease in maintenance and inspection, the control equipment is located

with the rest of the operating equipment.

It is the selection of the control equipment that brings out the major difference in perspective between the pump engineer and the control engineer. The former thinks in terms of total dynamic head. In short, his concern is the delivery of water from the source to an ultimate point at a given rate and head. He does not particularly care how or where the water is to be used en route as long as the pump is adequate to supply the requisite flows under the maximum friction loss conditions. The control engineer, on the other hand, considers static (pump not operating) and dynamic (pump operating) conditions. He is vitally concerned with what occurs between the check valve at the pump discharge and the ultimate destination of the water pumped.

Starting the pump seldom presents a problem for the control engineer. In the majority of systems, he is dealing with a relatively stable condition, except for pressure fluctuations due to surge which are completely compensated for within the control. In a system using an elevated tank, with running surges washed out, the static pressure at the pumping station is a definite reflection of tank level.

By the same token, the control engineer is not concerned with friction loss so long as it is a constant. Friction loss can be readily compensated for by modern control equipment. Anything that varies the friction loss within the 24-hr period, however—such as intermediate drawoff or suction pressure change on the booster pumps—becomes an immediate and important problem. Variable friction often renders control from the pumping station difficult and at times impossible. As friction variations occur only under dynamic conditions, it is far more difficult to stop the pump accurately than it is to start it. It should be noted that single-pump remote controls cannot be safely used for a multipump installation because they do not provide the essential electrical interlock required to compensate for changes in friction loss that occur as additional units are brought into service. This protection is provided by multipump controls.

The second approach to pressure control of peripheral distribution is

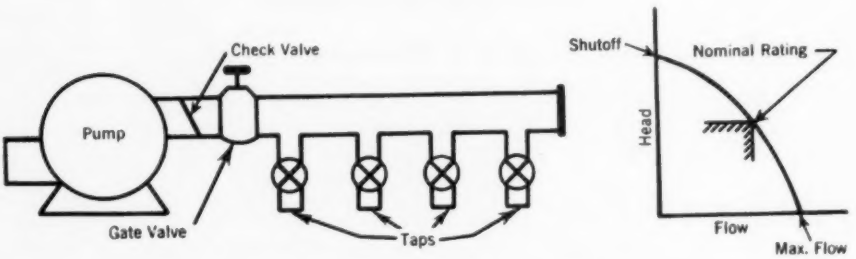


Fig. 1. Simplified Distribution System

The pump characteristic curve on the right indicates that, at shutoff head, the pump develops maximum pressure, while, at zero head, it delivers maximum flow.

through the use of the hydropneumatic tank, a method that is not generally suited to this type of operation, as it lacks a reserve for power outage or other emergency conditions and is completely dependent on the pumping source. In such applications, the sole function of the pressure tank is to stabilize the system and to permit a modicum of efficiency in control. It does not provide storage and, without standby motive power, can conceivably engender a false sense of security for which there is no place in modern design.

The third approach to peripheral distribution is through the use of the closed system or direct pumping. The water to be used in this system is obtained by means of a direct connection to an existing distribution grid or aqueduct, by means of an indirect connection to the primary supply through a clear well or ground storage, or from an independent well field supply, pumping either directly into distribution or into a treatment plant.

For municipal systems, even when they incorporate an industrial load, the problem of pressure control is

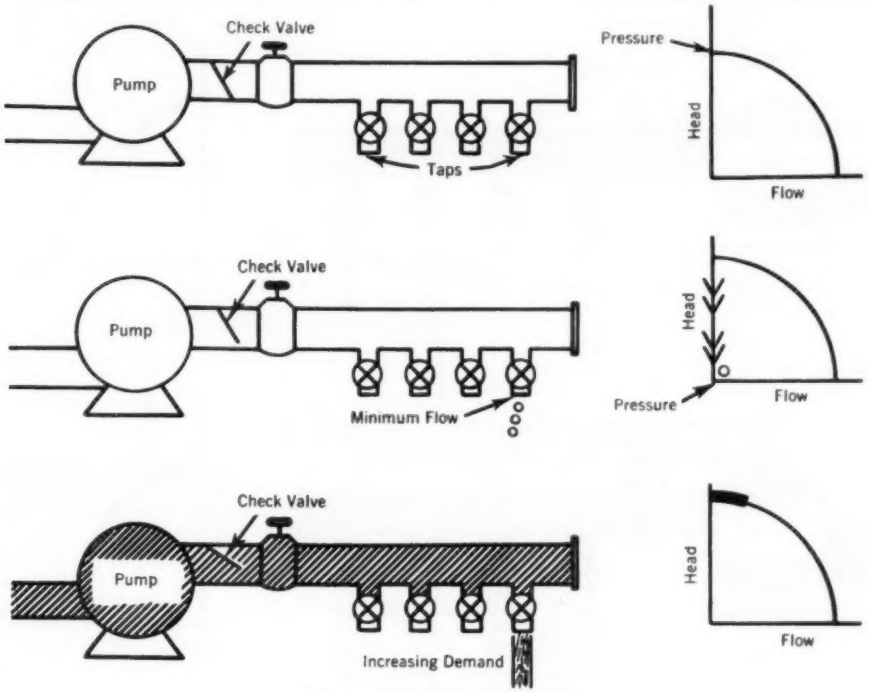


Fig. 2. Condition at Shutoff

With the pump not operating and all taps closed, the pressure remains at the shutoff head. When one tap is opened slightly, the pressure immediately drops to zero. With the pump running, gradually opening one tap causes the pressure to drop as indicated by the heavy line on the pump curve.

simplified by the fact that demand follows established trends. Experienced water works operators know that the time of day and the season of the year are reflected in the flow charts. The knowledge that human beings are creatures of habit and slaves to their timepieces can be put to good use in dealing with pressure control.

the ultimate objective. Thus, the problem—and the goal—is to supply the demand, whatever it may be, while maintaining a pressure norm within the narrowest possible limits.

The left side of Fig. 1 shows a simple sketch of a pump connected to a short length of pipe with several taps. In principle, there is no difference be-

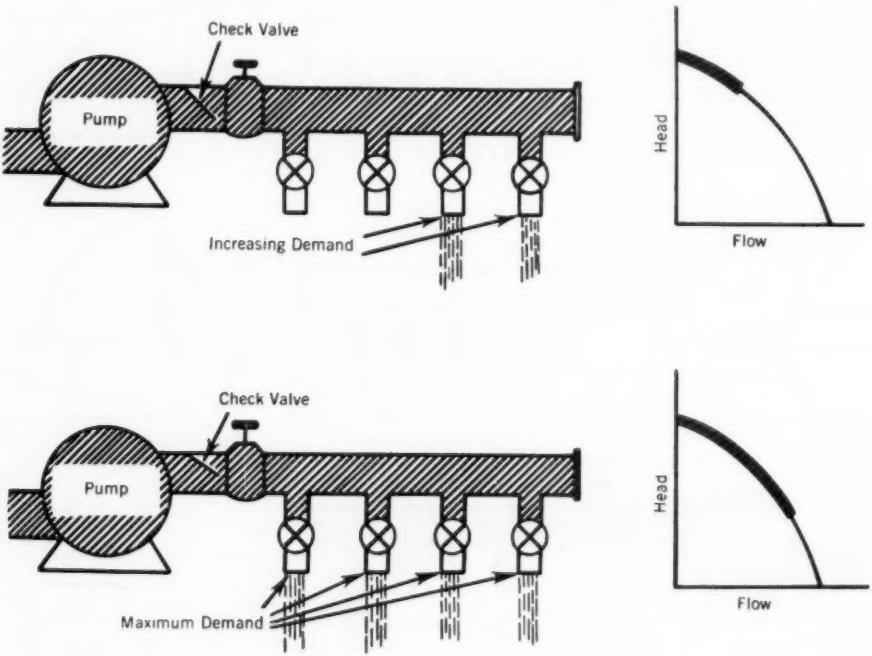


Fig. 3. Effect of Increasing Demand

Increasing demand causes a gradual drop in pressure, as shown by the heavy line on the pump characteristic curve.

Flow and Pressure

The two fundamental factors in any water distribution system are flow and pressure. It is impossible to concentrate on one and ignore the other. Broad variations are inevitable in demand or flow, but constant pressure is

tween the short length of pipe with a few taps and a section of main with many laterals and taps. At the right of Fig. 1, a typical pump curve is illustrated. As a rule, pumps are thought of as having a capacity of 500 gpm at 200-ft head or 1,000 gpm at

100-ft and so forth, but that refers only to the nominal rating of the pump. Every pump has a characteristic curve. At zero flow, the pump is at its shutoff head, the highest pressure it can develop. Conversely, at zero head, the pump is discharging its maximum flow.

If all the taps are tightly closed (Fig. 2, top) and there are no leaks in the system, starting the pump causes the pressure to go immediately to the shutoff head and remain there. Again assuming that the check valve and system are leakproof, the pressure would literally remain in the system at the shutoff head of the pump with the pump shut down. When one of the taps is opened only a slight amount, however, the pressure immediately drops to zero. With the pump back in operation, if the same tap is gradually opened until it is discharging at a maximum, the pressure in the system drops as indicated on the curve in the bottom illustration of Fig. 2. This single tap may represent 1,000 taps in a large system. As other taps are gradually opened, simulating an increased demand, the pressure creeps further down the pump curve (Fig. 3), and the pump discharges a greater quantity but at a lower head.

As the taps are closed, the pressure climbs back up the curve until, at zero discharge, the pump is once again at its shutoff head. Continued operation under these circumstances would cause damage to the pump. Therefore, it is expedient to insert a small bypass from discharge back to suction (Fig. 4), with a mechanical relief valve set to intersect the pump curve at some point below the shutoff head, thus permitting enough water to recirculate to

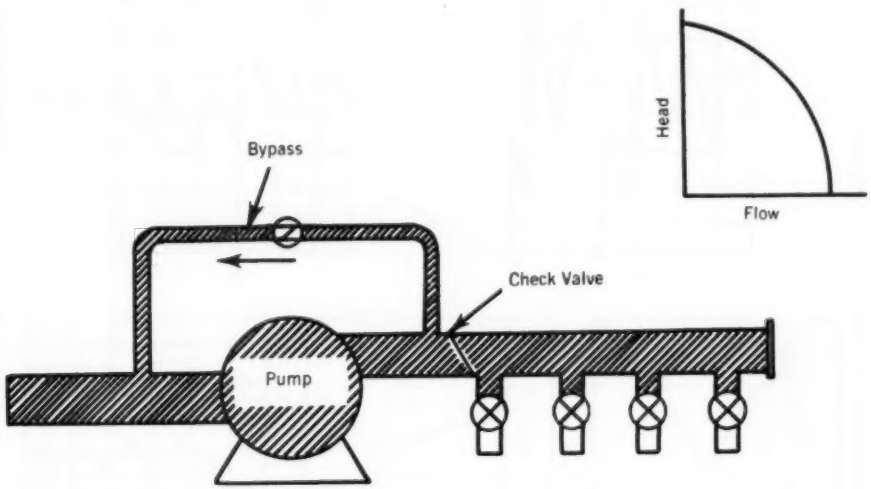


Fig. 4. Bypass Installation

A bypass around the pump permits recirculation of water during periods of minimum demand.

keep the pump cool. The premises so far established by these simple illustrations can be applied on a practical basis.

Pump Selection

From the foregoing, it is immediately obvious that the type of pump selected plays an important role in the application. Without question, there is more to the selection of a pump than merely consideration of capacity, head, and efficiency. The characteristic curve is important to any system, whether controlled automatically or manually. For example, in a system using an elevated tank, a pump with what might be called steep-curve characteristics is preferable. Such a pump exhibits a relatively small change in flow rate for a substantial head variation (Fig. 5c). With an elevated tank, where the problem is to supply a constant rate of flow, thereby stabilizing the friction loss factor, this pump is ideal. Pumps with such characteristics are totally unsuited to a system without storage, although, unfortunately, they may be thus improperly

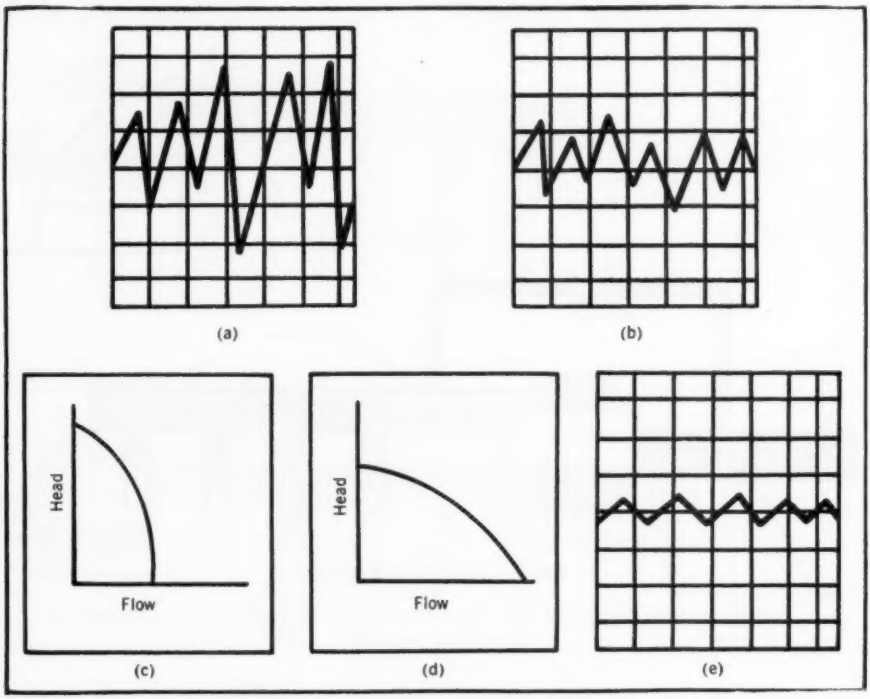


Fig. 5. Elevated-Tank System

Key: (a) pressure chart, pump not operating; (b) pressure chart, pump operating; (c) and (d) pump characteristic curves; (e) pressure chart showing reduced fluctuation when flat-curve pump is used.

applied through force of habit. The closed system requires a pump with the opposite characteristic—that is, a flat curve which will produce the broadest possible change in flow for the smallest change in head (Fig. 5d).

In a closed system, the pump, if properly selected, can be utilized as a flowmeter, and no orifice plate or venturi tube is needed to operate the controls. As previously pointed out, the curve, flow can be accurately measured by pressure and careful pump selection can minimize the pressure variations.

From the standpoint of surge and fluctuation, the closed system is probably the most stable system of water distribution. In the elevated-tank system, during periods when the pump does not operate and the tank supplies the demand, the pressure charts

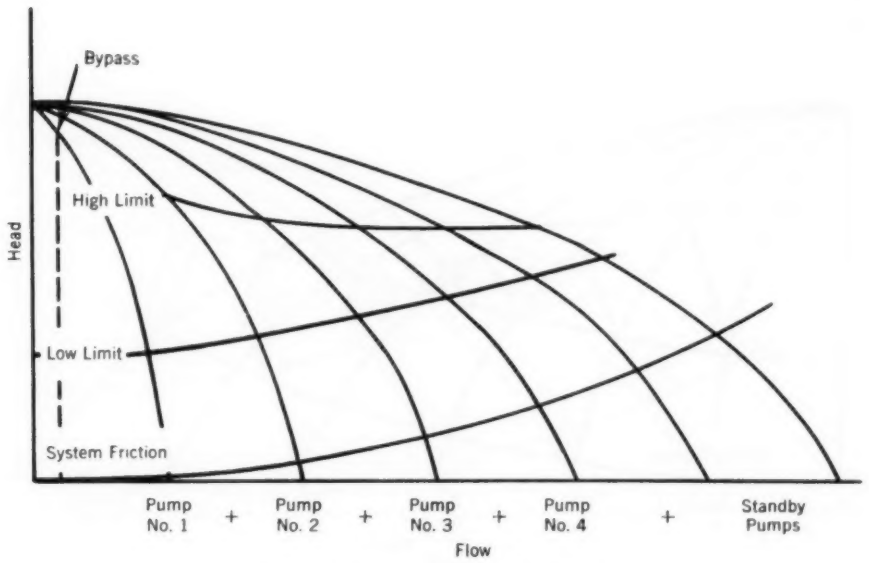


Fig. 6. Sequence Operation Curves

When each pump is added, the corresponding curve applies.

pressure drops with an increasing flow and rises with a diminishing flow. Ideally, the pressure should be held as nearly constant as possible. The limits of pressure variation are determined not by the control but by the pump characteristics. It is apparent that the flatter the curve, the smaller will be the variation. It can be safely stated that, from the pump characteristic resemble Fig. 5a. With the pump operating, the magnitude of the running surge is reduced as in Fig. 5b, because the pump characteristic curve takes up the slack, as it were, in the demand variation that was causing the surge. This is true even with the steeper-curve pump (Fig. 5c) generally employed on elevated-tank systems. It is obvious that the flatter-

curve pump (Fig. 5d) will absorb even more fluctuations and, other conditions being equal, will reduce the range of running surge still further, as shown by Fig. 5e.

Assuming, for example, that a closed system has a high-service pumping station drawing from ground storage with a constant suction pressure, consideration must be given to two factors. There will be a broad range of demand to supply, varying from the absolute minimum to the absolute maximum emergency peaks, plus an adequate safety factor. Also, it is uneconomical to operate more horsepower than is required to do the job at any time. The number and type of pumps must be selected with these two considerations in mind.

Sequence Operation

The lead pump should have a nominal rating approximately equal to the minimum demand. In sequence operation, multiple pumps of equal rated capacity and identical characteristics are used. Figure 6 shows composite characteristic curves for such a group of pumps. The system friction curve at the bottom of the graph is important as it determines the location of the transfer point in sequence operation. The intersections of the two horizontal lines marked "low limit" and "high limit" with the character-

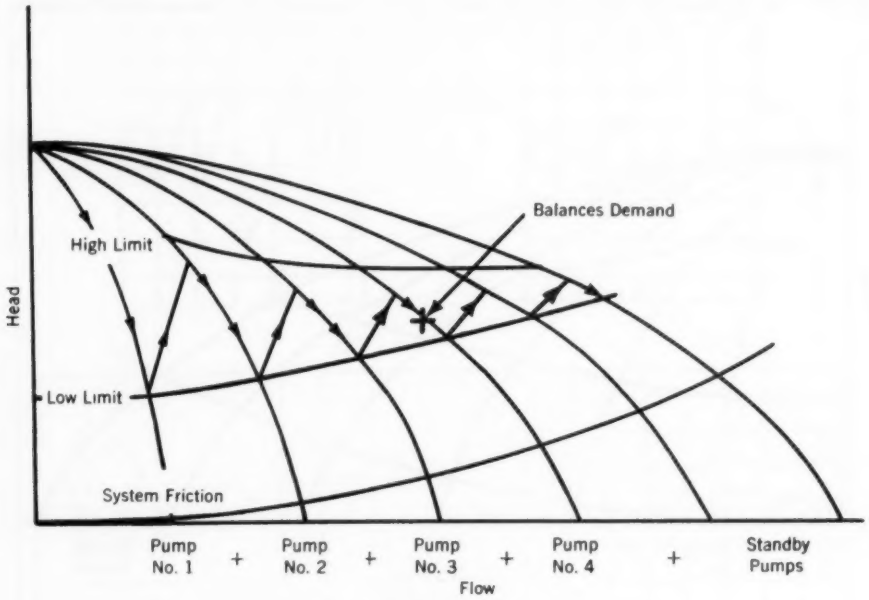


Fig. 7. Sequence Operation to Meet Increasing Demand

The intersection of the high-limit line with the characteristic curve marks the point at which the control brings an additional pump into operation.

istic curves are control points. Should the demand ever fall to the point marked "bypass," a small bypass line from the pump discharge, either back to suction or to the ground reservoir, will cause circulation to protect the pump. This arrangement is needed only for the lead pump.

To maintain pressure on the system, which is similar to the small length of pipe previously discussed, one pump must run continuously. This is the lead pump, selected for minimum demand only. As the demand steps up, the flow increases and the pressure drops to the intersection of the low-limit line and the first pump curve (Fig. 7). At that point, the control transfers and introduces a second pump, increasing the pressure as indicated by the arrow. With increasing demand, the pressure decreases along the second pump curve (for pump No. 1 + No. 2). Each time the low limit is reached, the control transfers the system to the next curve by introducing an additional pump, until the demand stabilizes at some point. Naturally, the control provides for all time delays necessary to prohibit excessive starting and stopping. Because demand is on a trend basis, a time element is introduced by the system itself. Under normal conditions, the demand will remain in an area around the balance point for a

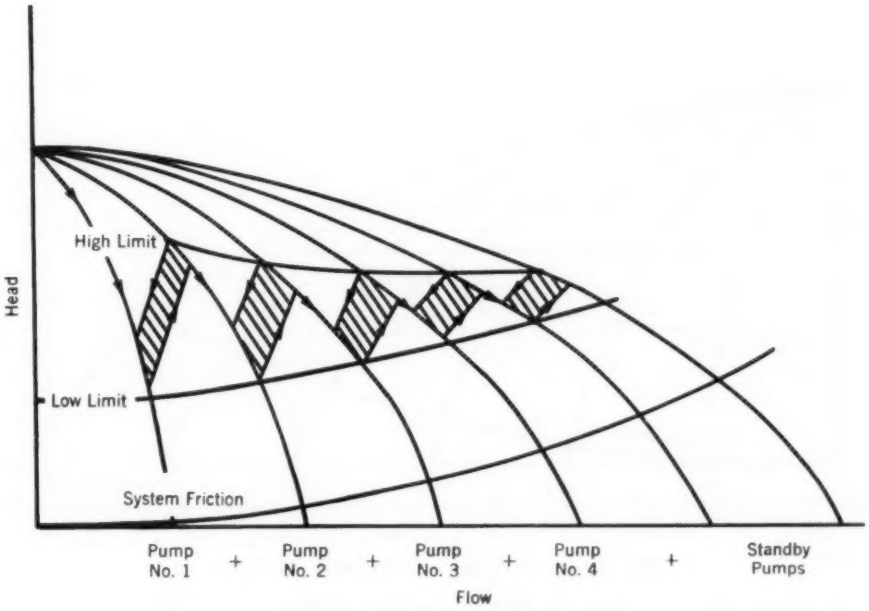


Fig. 8. Provision for Overlap

In making transfers from one curve to the next, sufficient overlap must exist in the system to prevent "hunting."

while and will then increase further or gradually diminish.

When the trend reverses, the pressure ascends along the pump curve until the high-limit line is reached. At that point, the control transfers the system back to the preceding curve, cutting out the last pump. This process continues as the demand falls until it again stabilizes. Each time the high limit is reached, the capacity is reduced and the demand is supplied with less horsepower.

It will be noted that, when the change in demand causes a shift to another curve, the intercept on the new curve is at a point below the high-limit (or above the low-limit) line. This is essential to prevent "hunting." An overlap such as indicated by the shaded area in Fig. 8 must be provided.

To approach the ideal of a constant pressure (represented by the "norm line" in Fig. 9), the high- and low-limit lines must be as close to the norm line as possible, a condition which depends on the shape of the pump characteristic curves. It should be evident that the flatter the curves, the narrower the field between the high and low limits will be. As previously mentioned, the shape of the curve is determined not by the control but by the type of pump selected. Consequently, in this type of system, it is not enough to specify a nominal rating for the pump; stated deliveries at the high and low limits must be required, with the maximum pump efficiency lying between the limits.

The control is designed to operate the system smoothly, without shock and surge. There is no need for ma-

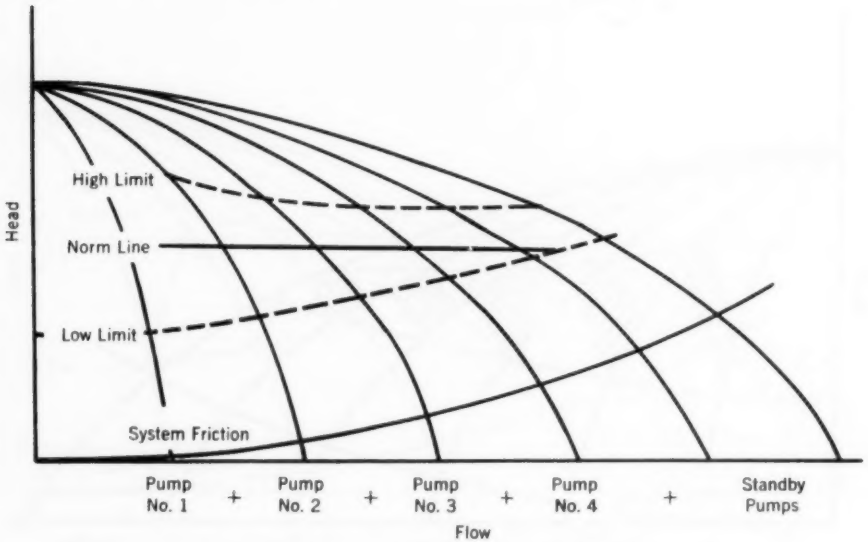


Fig. 9. Curve Shape and Pressure Variation

The "norm line" represents the ideal of constant pressure. The flatter the characteristic curve, the narrower the field between the high and low limits will be.

nipulating valves or using hydraulically operated cone valves in lieu of swing checks, if the pumps are properly selected and the system is properly controlled. This system is almost foolproof. For example, if one of the pumps in the sequence is disconnected, the control automatically continues to call for pump operation, and the standby pumps cut in.

designed to operate under both normal and emergency conditions, provided automatic cranking equipment is supplied for the engines. What is more, should an outage occur during multipump operation, when the transfer is made to the standby motive power or the original power is restored, the control immediately starts only one pump, recycles completely,

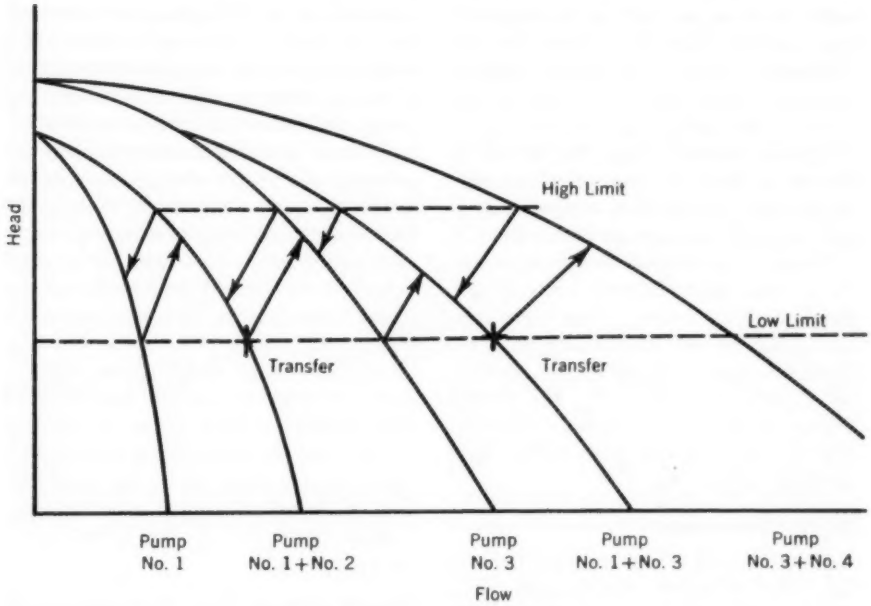


Fig. 10. Programmed Operation

A group of four pumps arranged for five-step programmed operation is shown.

Standby Motive Power

A word of caution is advisable. Obvously, this type of system is completely dependent on the pumping source. It is, therefore, necessary to have standby motive power, either a dual drive on some of the pumps or, preferably, an engine generator set capable of handling the pump requirements. In either event, the control is

and then adds additional capacity on a time basis until the demand load is again balanced.

Programmed Operation

There is a second type of control for the closed system—programmed operation. In this method also, the lead pump is selected to meet the minimum demand, and the other pumps

are chosen to develop a composite curve to meet all the requisites previously indicated. Figure 10 shows a composite curve for four pumps in five steps. Two pumps are of one size and two of another, a practical selection that not only provides standby facilities but, more important, also helps to equalize pump wear by permitting alternation.

The operation of this system is exactly the same as that of the sequence type, except that the control has an additional, very important, feature. When a smaller pump is to be cut out in favor of a larger one, or vice versa, the pump control keeps the former in operation until the new one can pick up the load. Otherwise, surges will occur, causing damage to the system.

Properly controlled, the pump transfer is smoothly effected, without any shock to the system. The time control must be set empirically to meet the conditions existing in the particular installation. Actually, the proper timing is arrived at through observation of the pressure gage rather than through calculation.

Direct Connection

If the pumps are connected directly into the primary distribution grid, there may be times, especially at night, when the primary-system pressure is adequate to supply the need of the suburban area. During these intervals, this pressure is used in place of the lead pump, and none of the pumps in the booster station run. Under such conditions, the control is equipped to measure the suction pressure on the pumps, and, whenever it falls below a value that is adequate to supply the new area, the lead pump is started. The control is interlocked so that, once the lead pump is started, the control measures the pressure—and, hence, the flow—in the suburban system proper and operates the rest of the pumps in accordance with the demand in that area. In other respects, the control works exactly as previously set forth, either on a sequence or on a programmed basis. Should the pressure in the primary system again become adequate to supply the suburban demand, the booster pumps are stopped. In selecting the pumps, consideration must be given to the range of suction pressure changes which will cause the pump characteristic curves to shift.

If there is a direct connection to the primary system but the pressure in the latter is never adequate to supply the secondary demand, one pump must run continuously, as with a ground reservoir source. Where broad ranges of suction pressure variation exist, the control must sometimes sense the suction pressure and divide it into definite zones to provide smooth operation of the system. This type of control utilizes as many individual sensing elements as are required by the combination of suction pressure zones and resultant variations in the system friction curve.

Closed System Plus Elevated Tank

If a suburban area has an elevated tank that is no longer adequate, the principles of closed-system operation can be adapted to the situation. A check valve is added to the main supply line to the tank, so that water can flow from but not into the tank via that route. A small bypass, roughly one-half the size of the main line or less, is installed around the check valve with a motorized valve in the bypass. The motorized valve has a very sensi-

tive and accurate control, which measures the actual tank level. The entire system is then operated on the principles of a closed system, of either the sequence or the programmed type.

In normal operation, the pressure at the check valve, at the base of the tank, is maintained at a higher value than the tank elevation. For example, with a tank height of 115 ft, the pressure at the check valve would normally be kept at 55 psi (approximately 127 ft). Thus, if a high-demand area beyond or adjacent to the tank or excessive friction loss in the system during a high-demand period caused the pressure to fall, the tank would enter the system to supplement the pumps. As soon as the tank level was reduced by a few feet, the sensitive control would open the motorized valve, so that, when the demand decreased, the tank would be replenished immediately and would await the next low-pressure condition. In the event of pump outages, the tank, of course, would supply the system.

This method is the only one by which an elevated tank can be used in conjunction with a closed system. Were the tank riding on the line, as is typical of an elevated-tank system, the pump would no longer be a flowmeter and closed-system principles would not apply. The method described, however, makes it possible to have one's cake and eat it, too. It provides storage for emergency purposes while offering the advantages of the closed system—stability and efficiency. At the same time storage is kept to minimum requirements.

Discussion

Lewis S. Finch

Vice-Pres. and Chief Engr., Indianapolis Water Co., Indianapolis, Ind.

Automatically controlled pumps are effective in developing or boosting water pressure in a suburban distribution line. Although they will often serve as a satisfactory substitute for an elevated storage tank during the period in which a suburban area is being built up, they cannot equal the continuity of service that an elevated tank floating on the line will assure. Automatic controls, like other automatic devices, are not foolproof, nor can they be expected never to cause trouble. They require a minimum of care and attention, but sooner or later a fault will develop, resulting in erratic control of pumping equipment. Automatic controls have, however, reached such a state of dependability and will control pumps so effectively that suburban areas adjacent to Indianapolis, Ind., for example, have been granted eighth class grading by fire insurance underwriters—provided the insured risks are within 1,000 ft of a fire hydrant and within 3 miles of a city fire department. Indianapolis, on the other hand, enjoys a second-class grading.

It is important that the distribution system be studied carefully in order to select pumps which will have characteristics in keeping with existing pressure and friction conditions. In pumps taking suction from an existing distribution system, pressure conditions on the suction side of the pump must be analyzed and the automatic control equipment, as well as the pumps, must be designed to meet these conditions. In fact, it is important that the loca-

tion of the station itself be chosen only after a study of the pressure conditions that may be expected to prevail on the suction side of the pumps while they are operating. If it should be found that there is a wide variation in suction pressure, the automatic control of discharge pressure will become more complicated, and the controls must be designed to reckon with it. If the suction pressure drops to low levels and the controls are not designed to overcome this condition, the control mechanism, in an attempt to develop proper discharge pressure, may select a pump which will deliver more water than the system requires. Under these conditions, the discharge pressure may be so high that the controls will cycle back to a smaller pump, with resultant inadequate pressure on the discharge side, and hunting will occur. This danger can be met by building pressure zone controls into the control panel, as described by the author.

It might be thought better to adopt quantity rather than pressure control. Low suction pressure and low quantity demand would still present a problem, however, as, under these conditions, the controls would not select a pump that would develop the required head.

Before choosing pumps and automatic control equipment for a large distribution system, it should be determined that the withdrawal of fire flows at remote points on the system will lower pressure at the station sufficiently to cause the pump to deliver enough water or the control to select a larger pump. Usually this drop will occur, but it may not in systems with a great deal of head loss between the station and the point of withdrawal. The difficulty can be overcome by leasing telephone circuits and telemetering the pressure from remote areas to the station where the automatic controls are located. Automatic controls can be made to work under such circumstances, but the installation of an elevated tank in the remote district will probably be the only completely satisfactory solution.

It is true, as the author states, that in a closed system the pump can be employed as a flowmeter and that, if the pump is properly selected, no orifice plate or venturi tube will be needed to operate the controls. Nevertheless, some form of meter other than the pump will be required if the flow is to be measured accurately.

The author quite properly has indicated the need for a bypass back to suction around the lead pump lest it damage itself by operating at shutoff head when there is no withdrawal from the system. The statement that such a bypass will be needed only around the lead pump is open to question, however. To be completely safe, it would be well to have a bypass around each of the pumps. A jammed check valve may result in the same conditions as would prevail if there were no withdrawal from the system, or a larger pump may develop sufficient head to shut the next smaller pump completely off the line with the same results in the event that the controls fail to function properly.

The efficient operating range of a sequence of pumps subject to automatic control should be established, and controls should be selected to insure that the pumps operate within these limits.

Although automatic controls can be designed to minimize surge, they should not be depended on to prevent it completely. For example, they can

exercise no control over surges resulting from a sudden stoppage of all pumps caused by power failure. Therefore, hydraulically operated cone valves should be considered when large volumes of water are being pumped with resultant high velocities in the pipelines.

Large systems with competent personnel at the central pumping station may favor supervisory rather than automatic control. In the event of rapid fluctuation of demand, however, supervisory controls cannot be expected to be as effective as automatic equipment. With an elevated tank upon the system, such fluctuations probably would be ironed out, with the result that supervisory control might be workable.

Signal Systems

In large suburban areas or areas in which important water-using industries are served, it is advisable that automatic control systems be supplemented by signal systems that will inform the operators on duty at the central station of conditions in the suburban service area. Pressure can be telemetered over leased wires, and, if sequenced properly, coded signals also may be transmitted over the same pair of wires to indicate power failure or operation of a standby gasoline engine, for example.

One of the Indianapolis booster stations has been equipped, for less than $1,000, to indicate by means of a code when any one of five conditions prevails in the station. This system, operated from the station's 12-v d-c battery circuit, is designed to transmit coded signals from the booster station to the main pumping station when certain eventualities occur. The signals are registered at the main station both by the sounding of a horn and by the flashing of a red light. When the operator's attention has been attracted by the horn, he can turn it off, but the red light will continue to flash as long as the condition prevails. As soon as the horn is turned off, a white pilot light automatically goes on to indicate that the horn has been disconnected from the signal system.

The signals are either continuous or a series of shorts (1 sec on, 1 sec off) repeated at 30-sec intervals:

1. *Continuous.* This signal indicates either a three-phase or a single-phase power outage, or else an open circuit fault in the telephone line. If the signal results from a power failure, it will continue until the power is restored or the gasoline engine is started. In the latter event, the signal will automatically change from continuous to two shorts (explained below). The power failure signal is activated by the operation of the auxiliary contacts of undervoltage relays.

2. *Two shorts.* This signal indicates that the gasoline engine is running as a result of a power failure, or that the largest electric motor failed to start when called for. The signal is actuated by a sequencing cam unit operated by an auxiliary relay in the engine d-c generator circuit.

3. *Three shorts.* This signal means that the largest pump is being called on to operate on normal duty. It is desirable to know when this pump is operating in sequence, because this fact indicates a demand for an excessive amount of water on the distribution system, possibly owing to a main break or a large fire. The signal is

actuated by an auxiliary relay connected in parallel with a relay of the automatic control system.

4. *Four shorts.* This signal shows that the largest pump is being called upon to operate on emergency duty, indicating that, for some reason, one of the smaller pumps has failed to start. The signal is actuated by an auxiliary relay installed in the automatic control system.

5. *Five shorts.* This signal indicates that the temperature in the washroom at the booster station has fallen below a predetermined point and that the water in the small piping is in danger of freezing, presumably because of failure of the gas-fired unit heater to operate. The signal is actuated by the auxiliary thermostat in the washroom, which can be set to operate the signal at temperatures between 25° and 60°F.

This signal system is so simple and relatively cheap that it would be advisable to supplement automatic controls with it. In that way, the main station operator can find out about faulty operation without waiting for customers to inquire or complain. The system will pay for itself in improved public relations.

Water Works Civil Defense Manual Issued

Civil Defense Manual TM 13–2, "Operation and Repair of Water Facilities in Civil Defense Emergencies," has been issued by the Federal Civil Defense Administration. If copies are not available at state or local civil defense offices, they can be obtained from the Supt. of Documents, U.S. Govt. Printing Office, Washington 25, D.C., at a cost of 25 cents each.

Meeting the Dallas Water Shortage

By K. F. Hoefle

A paper presented on Oct. 21, 1953, at the Southwest Section Meeting, Houston, Tex., by K. F. Hoefle, Supt., Dallas Water Works, Dallas, Tex.

THE water situation in which Dallas, Tex., found itself in the autumn of 1952 cannot be fully understood without a look at events leading up to that time.

At the outset of World War II Dallas had a fairly ample supply of water and a well-balanced water system. Good planning had enabled the department to keep up with demands imposed by the growth of the city. In 1944–45 an engineering firm prepared a master plan of development for Dallas. At the same time, based on data provided by this firm, H. A. Hunter, then superintendent of the water department, worked out a long-range program of improvement for water supply and distribution from 1945 to 1970. His conclusion was that the existing supply would suffice until 1963, and he recommended the construction of an additional storage reservoir in 1959–61 to provide a supply extending beyond 1970.

Prior to the war the U.S. Army Corps of Engineers had prepared a plan for flood control and eventual navigation of the Trinity River. Authorization had been given by Congress, but no appropriation had been made when the war put a stop to the whole project. In 1946 the corps was ordered to review this project.

By that time it was clear that the rapid increase in water consumption during the war years would not taper off with the return of a peacetime economy. All signs indicated that Dallas was at the beginning of a great surge of growth, and this prediction has turned out to be true. In common with other cities of the Southwest, Dallas has experienced a phenominal expansion, the end of which is not yet in sight.

Therefore, in 1946, when the Corps of Engineers undertook a review of the Trinity River project, Dallas filed a brief. Because the corps' original plan had preempted three of the relatively few suitable reservoir sites on the city's watershed for flood detention reservoirs, with insignificant storage for navigation, the corps was urged to make revisions in order to give full consideration to Dallas' dependence upon that drainage area and to exploit its resources completely. If this was not possible, no plan should be adopted that would prevent development needed by the city or make it too costly. In requesting that maximum conservation storage be provided behind each dam to be built, the city agreed to pay the additional expense involved.

In response, the Corps of Engineers presented a plan to include a total of 395,000 acre-ft of storage in two reservoirs for Dallas, in addition to 71,000 acre-ft for other localities. This storage is estimated to be the net amount available after 50 years, additional silt storage space having been provided for that length of time. As Lake Dallas net storage 50 years hence

will be 105,000 acre-ft, a total of at least 500,000 acre-ft will be at hand for 50 years. The smaller of the two reservoirs, Grapevine, has been ready for storage since July 1952 but, to date, has received only a little runoff. The larger reservoir, Garza–Little Elm, will be completed early in 1954. It is now estimated that the safe yield from the Dallas total storage of 500,000 acre-ft will be sufficient until approximately 1970, by which time additional supplies must be available.

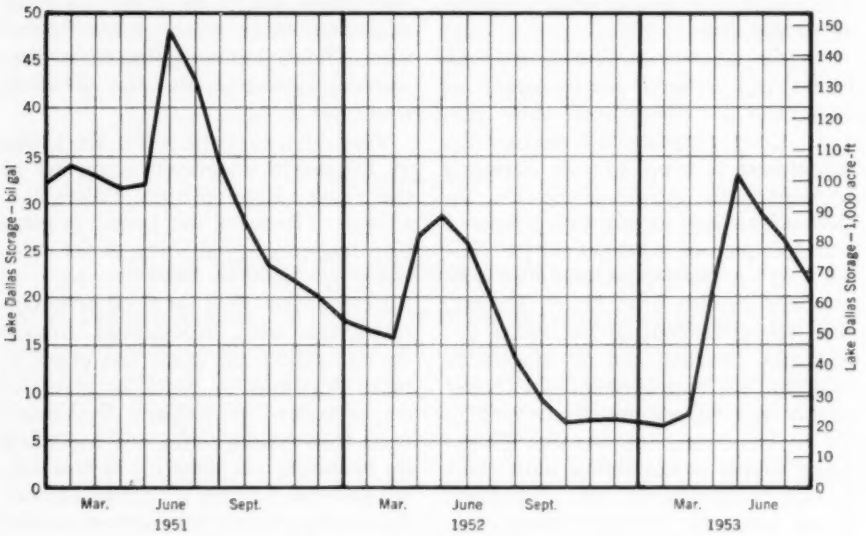


Fig. 1. Lake Dallas Storage

Storage is shown as of the end of each month.

Extent of Emergency

Since 1949 both the Dallas area and its watershed have experienced a period of declining rainfall. Although Lake Dallas, the principal supply source, was almost filled in June 1951, there immediately followed an unusually hot, dry summer. The great number of new houses demanding large volumes of water for lawns and shrubbery, together with additional demands due to expanding industry and increasing use of air conditioning, created the greatest draft on available supply that had ever been experienced. The consequent decline in storage and absence of replenishing runoff is graphically shown in Fig. 1. From June 1951 to March 1952 the supply diminished from 149,000 to 48,000 acre-ft. Not until April and May of 1952 did replenishing runoff occur. Through October, the 1952 rainfall was only 17.7 in., against an average of approximately 30 in., and the runoff was even less than in 1951. For the first year since 1927 the lake fell far short of filling. The summer of 1952 had a record-breaking number of days on which the temperature exceeded 100°F, and the relative humidity remained very low. The summer

demand increased in amount and duration as more air-conditioning systems were installed and residents strove to keep alive lawns and shrubbery. Figure 2 shows the rising trend in pumpage.

Under the conditions prevailing during the summer of 1951 and 1952, losses by evaporation from the lake surface greatly exceeded demand. By October the rapidly shrinking lake led to doubt that estimates of reserves were correct. When this fact was coupled with the possibility that fall and winter rains again might not occur, the outlook was disquieting. In October 1952 a supersonic survey of the lake, conducted by the Corps of Engineers, revealed that it did contain less than had been estimated—enough for only a few months' supply at the current rate of use. Although consumption was dropping with the advent of cooler weather, it was evident that an unusually large winter runoff would be needed if normal demands were to be met before the spring rainy season.

On Oct. 17, 1952, the city council passed an ordinance prohibiting all water use for irrigation, car washing, nonrecirculating air-conditioning equipment, swimming and wading pools, fountains, and street washing. At the same time conservation appeals were made. Large users were asked and helped to ferret out wastes and institute economizing measures. The response of the public was good, and consumption was quickly reduced from 76 to 47 mgd, or 38 per cent.

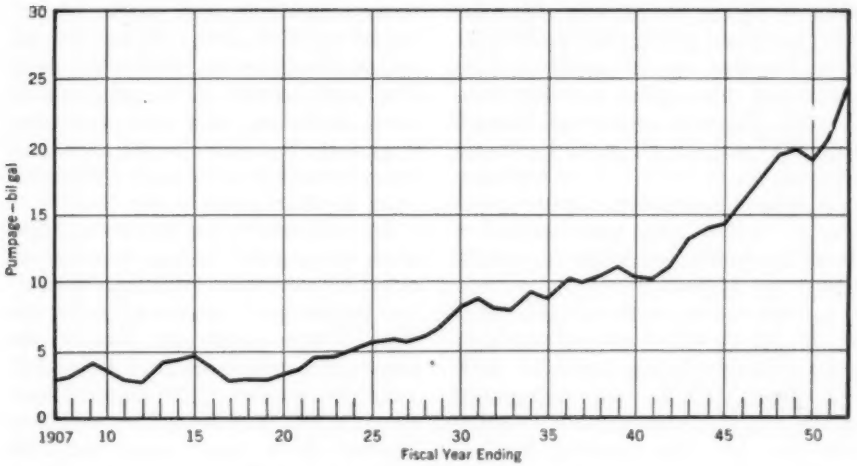


Fig. 2. Primary Pumpage at Dallas

A steadily rising trend is indicated.

Emergency Supplies

Dallas owns three small lakes, of which the two larger, Bachman and White Rock, lie within the city limits and were formerly used for water supply but have since been devoted to park and recreation uses. The contents of Lake Bachman and the third lake, Willow, were immediately drawn upon, as they are so situated that they

can feed the Bachman treatment plant. These two lakes contributed 672 mil gal through June of 1953. By that time both had become seriously depleted. The White Rock treatment plant, abandoned in 1931, had been dismantled and the equipment sold or shifted to the Bachman plant. The buildings remained, however, and installation of equipment was started at once by water department forces. Production from this plant began on Dec. 26, 1952, reaching a maximum rate of 20 mgd, although it was originally designed to provide 15 mgd. The maximum permissible flashboards were installed on the spillway crest and spring rains spilled over the flashboards. The total production through July 1953 was 2.3 bil gal, a significant contribution to the city's requirement.

A firm of consulting engineers employed by the city recommended a threefold course of action to obtain emergency supplies:

1. Drill wells to the Travis Peak aquifer for a yield of approximately 25 mgd. This formation averages 3,000 ft in depth, and is being overpumped locally. It is the only prolific aquifer available, but the pumping level is rapidly declining.

2. Construct a temporary dam on the West Fork of the Trinity River below its confluence with Elm Fork at Dallas, backing water up Elm Fork to the weir below the Bachman intake, from which the water could be pumped into the forebay of the Bachman treatment plant.

3. Negotiate with Tarrant County Water Control and Improvement Dist. No. 1 for release of water from its Eagle Mountain Lake.

The city council adopted this program, and plans were prepared for the West Fork dam, but considerable controversy arose over the use of West Fork water, which receives the sewage plant effluent and industrial wastes of Fort Worth, Arlington, and Grand Prairie above Dallas. Despite assurances that the water could be made safe and, in any event, would not be used unless approved by the state and city health departments, public opinion prevailed and, on Dec. 2, the council ordered the abandonment of the West Fork plan.

Another engineering firm was hired to make an exhaustive investigation of possible sources of supply. Ground water conditions and surface water quality were studied. It was recommended that the city drill fewer wells than contemplated in the program already under way and that production from them be limited to 22 mgd during periods of peak demand, with lower rates at other times.

Several possible surface sources that were investigated had to be rejected either because their utilization by Dallas would have interfered with the Fort Worth supply or because the time and expense involved were considered excessive. Two sources, however, proved acceptable: the previously rejected West Fork below the Elm Fork confluence and the Red River near Gainesville. The West Fork was estimated to yield 25 mgd and the Red River 45 mgd, which, added to 22 mgd from wells, made a total of 92 mgd. It was contemplated that the city would enforce reasonable restrictions under which peak summer consumption would be limited to 91 mgd for Dallas and other communities dependent on the city's water supply. Thus, even the worst condition, no inflow to Lake Dallas, could be met.

Present Situation

The engineering firm's report was received in February 1953 and the

preparation of plans for the approved projects was commissioned. In the meantime, the city had begun a program of drilling five new wells and reworking two old ones in the Travis Peak formation. The total production from these seven wells was expected to be 14 mgd. One Travis Peak and nine Woodbine and Paluxy Sand wells owned by the city were pumped for a total of 4 mgd, and 3.5 mgd was obtained during the winter from the excess production capacity of six private wells.

Lake Dallas is an impoundment on the Elm Fork of the Trinity River, approximately 35 river miles upstream from Dallas. Tributaries both east and west of the river enter below the lake. Water withdrawn from Lake Dallas is released into the river, flows to Dallas, and is pumped from forebays at each treatment plant. This circumstance stood Dallas in good stead during the autumn of 1952 and the following winter. Light rains occurred with some frequency, and, although they resulted in insignificant runoff to the lake, it was possible for weeks at a time to meet the reduced demand from stream flow, without drawing on storage in the lake.

The cumulative effect of the use of water from other sources, coupled with economies in consumption, was to conserve the storage remaining in Lake Dallas during the period October 1952–March 1953. Reference to Fig. 1 shows a sharp contrast with the same period a year earlier.

Beside all these measures, the city engaged the services of the Irving P. Krick organization to conduct a 6-month cloud-seeding program, extending from Nov. 22, 1952, to May 22, 1953. That operation is the subject of another paper (see p. 1144, this issue) and will not be discussed here. A look at Fig. 1, however, shows at a glance that, during this period, the situation improved materially. Runoff between Jan. 1 and June 1, 1953, produced a net gain of 80,600 acre-ft in storage, almost equal to the total gain during the previous 2 years, 93,000 acre-ft. In addition and not included in any reserve estimates, approximately 20,000 acre-ft accumulated in Grapevine Reservoir.

When it was found that April runoff had produced storage in Lake Dallas equivalent to a year's draft from the West Fork project, the city council ordered further work on that controversial scheme suspended. The heavy construction had been done and equipment had been purchased but not installed.

The Red River project was completed on Aug. 10, 1953. Its six 9,200-gpm vertical pumps can lift 75 mgd against a total head of 293 ft, but it is estimated that the net minimum yield at Dallas may be as low as 45 mgd. Stream gagings to be conducted during pumping operations will supply more definite information on stream losses and yield.

With improved reserves on hand in May, the council relaxed restrictions on consumption, allowing water use for all purposes but limiting irrigation to alternate days. As a consequence, maximum daily demands have exceeded 140 mgd. The emergency supplies, however, have enabled this demand to be met with a reduction in draft upon Lake Dallas as compared to 1952. Although Dallas still lacks sufficient water reserve, its position is greatly improved and it is felt that all essential demands can be satisfied until the new reservoirs become operative.

Cloud-seeding Operations at Dallas

By Irving P. Krick

A paper presented on Oct. 21, 1953, at the Southwest Section Meeting, Houston, Tex., by Irving P. Krick, Pres., Water Resources Development Corp., Denver, Colo.

BEFORE discussing the Dallas, Tex., cloud-seeding operation, it may be well to describe briefly the general outlook and approach employed in commercial weather modification. The skilled commercial cloud seeder is qualified by training and experience to undertake the large-scale operations that make cloud seeding economically worth while. He is rarely concerned with the single cloud operation favored by the pure experimentalist, although commercial field techniques and operational procedures are, of course, based on a series of researches into cloud physics and precipitation mechanisms.

The qualified commercial operator recognizes that the effect of cloud seeding must be cumulative to be of economic value. Therefore, he attempts to build up in his target area, by continuous operations on all suitable cloud formations, a total effect that may be discerned over a long period as an increase in precipitation with respect to rainfall in surrounding, unseeded areas. He operates moving cloud masses, associated with migratory storm systems, in such a way that the seeded segment of the cloud system lies continuously over his target area.

The operational period of the commercial cloud seeder is a function of the total number and the duration of storms susceptible to cloud seeding. Hundreds of operational hours may be required before a significant (relative) increase in the precipitation recorded in a target area will satisfy the requirements for a true evaluation. (It may be remembered that the question of evaluation occupied a prominent place in an earlier paper (*1*) on the theory and practice of cloud seeding.)

TABLE 1

Storms and Generator Hours

Month	Generator Operation *hr*	No. of Storms*
1952		
Nov. 22–30	148.50	2
Dec.	51.15	3
1953		
Jan.	56.00	2
Feb.	130.90	4
Mar.	196.35	4
Apr.	157.55	5
May 1–22	129.10	2

* These figures give no indication of the number of operational days included in each storm, nor do they indicate the rating of each storm from the operational standpoint (good, fair, or poor).

Operational Procedure

The Dallas operation is an example of the large-scale type mentioned in the previous section. Undertaken as the result of a critical water shortage

in the city, it serves to demonstrate what cloud seeding can achieve, not only for the purpose for which it was initially instituted—raising the level of water in Lake Dallas—but also for the agriculture of the surrounding area.

The operation began Nov. 22, 1952, and ended May 22, 1953. During that time fifteen ground generators were operated for a total of approximately 870 hr. The monthly breakdown of generator hours and the number of seeded storms occurring in each month of operation are given in Table 1. The generator sites used at various times are shown in Fig. 1.

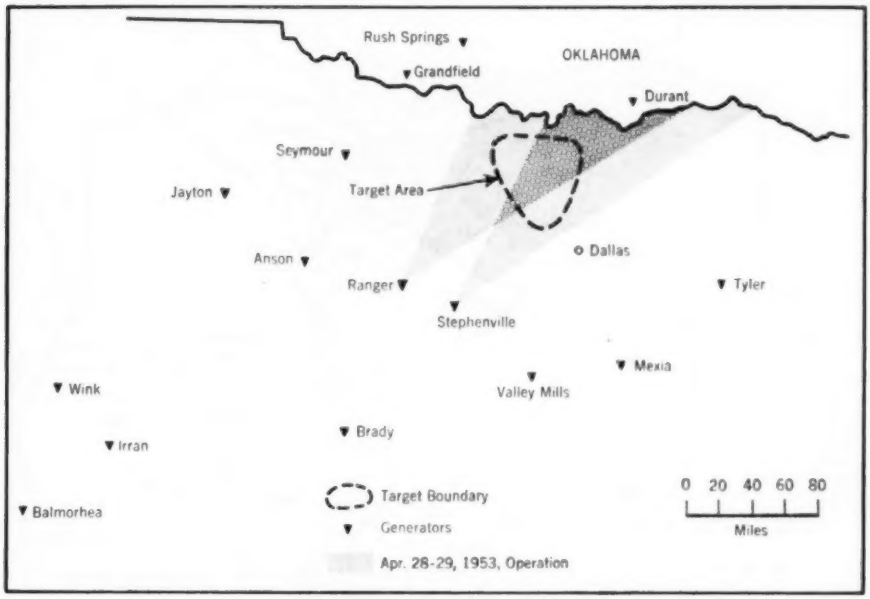


Fig. 1. Generator Sites

The locations of the generators used at various times during the Dallas operation are shown. The shaded areas indicate the spheres of influence of the two generators operated Apr. 28–29, 1953.

Operations typical of this project were undertaken on Apr. 28–29, 1953, for a storm that came into the Rocky Mountain area from the Pacific Coast on Apr. 28 and intensified and moved eastward to a position north of the Dallas watershed on Apr. 29. The freezing level was at approximately 12,000–13,000 ft, on the first day and at 10,000 ft on the second. Winds over Arizona, New Mexico, and Texas were southwesterly at the $-4°$ to 10°C level, where silver iodide is most effective.

The Stephenville generator was operated from 11:30 AM on Apr. 28 until 4 AM on Apr. 29 and again from 3 PM to 7 PM on that day. At Ranger, the generator was operated from 3 PM on Apr. 28 until 6 AM on Apr. 29.

Figure 1 shows the respective spheres of influence of the two generators, based on a consideration of wind direction and velocity at the effective level; moisture conditions at all levels; cloud type, height, thickness, and temperature; rate of rise of the silver iodide particles; and time of day. A silver iodide concentration eight times as potent as that normally used was vaporized on this occasion because of the high moisture content and excessive instability of the upper levels.

Total rainfall amounts for the two days of operation are shown in Fig. 2. Not only was the targeting remarkably good—the heaviest precipitation occurred right in the watershed area—but the cloud seeding also seems to have been responsible for extending the area of maximum precipitation from southeast Texas, where it "normally" occurs, to produce a secondary maximum in the vicinity of the watershed. Referring to Fig. 3, which shows the average April precipitation in the region, one can see that the southeast section of the target received the whole of its monthly normal from this storm alone.

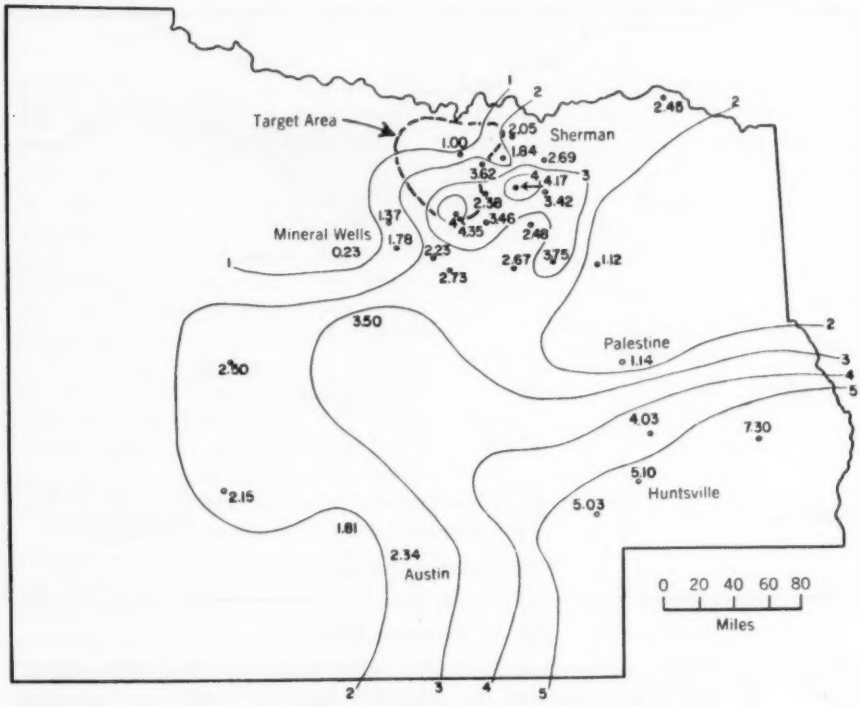


Fig. 2. Precipitation Pattern, Apr. 28–29, 1953

Rainfall as great as that of the "normally" wetter southeast part of Texas occurred in the southern section of the target area.

Results Obtained

Figure 4 indicates the percentage increase or decrease in water in storage

June 1, 1953, in relation to the Jan. 1, 1953, value. This information is shown for the Dallas watershed and for nearby watersheds affected by the same storms. It will be noted that Dallas, with its 363 per cent increase, has a large advantage over all the other watersheds. Similar data for the years since 1948 are given in Fig. 5. Although Dallas shows a large percentage increase in 1949, it is much less than the 1953 value, while percentage changes in the other reservoirs are so small as to be negligible in comparison.

Operational conditions during the project period varied greatly from month to month, and good seeding opportunities during the winter were relatively few. Table 2 shows the number of days (within the storm periods listed in Table 1) when conditions could be described as very favorable to cloud seeding. In spite of the scarcity of good operational conditions, the total precipitation for the period Nov. 22, 1952, to Apr. 30, 1953, expressed as a percentage of normal precipitation for these months, was much higher in the target area than in the surrounding territory (Fig. 6). As the normal precipitation is 16 in. (November–April total) in the eastern portion of the

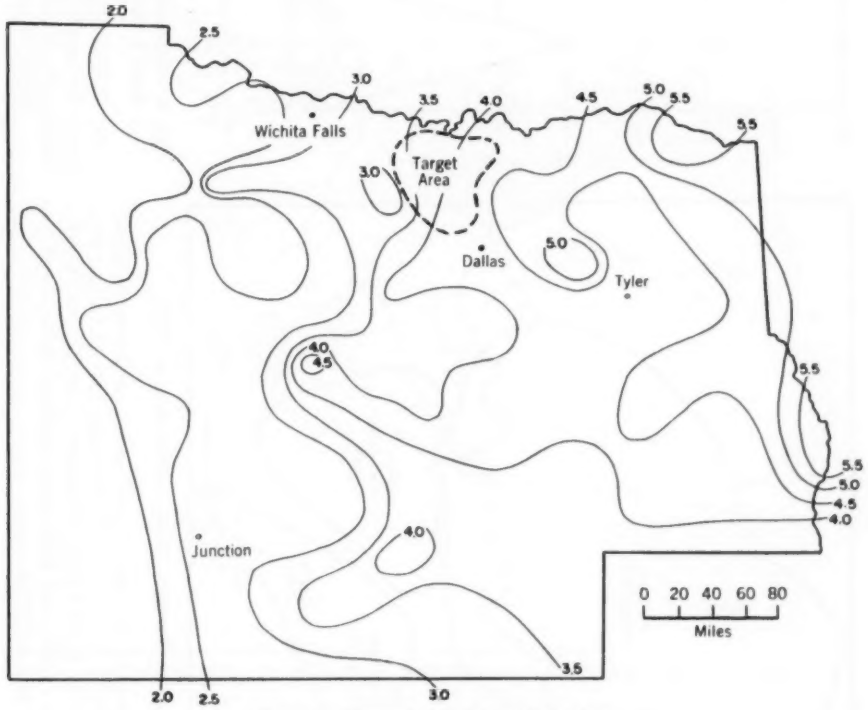


Fig. 3. Normal April Precipitation

Values are in inches. It will be noted that the Apr. 28–29 operation (see Fig. 2), by itself, resulted in as much rainfall in the southeast section of the target area as it normally receives during the entire month.

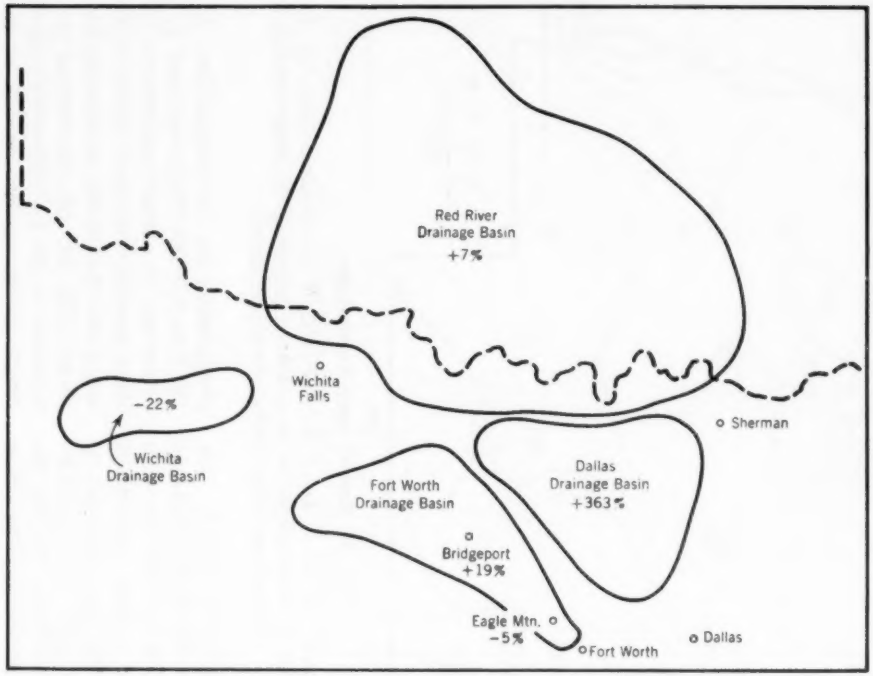


Fig. 4. Percentage Change in Storage, June 1 Over Jan. 1, 1953

The actual storage figures (in acre-feet) for Jan. 1 and June 1, respectively, were: Dallas drainage basin, 22,200 and 102,800; Fort Worth drainage basin (Bridgeport), 74,200 and 88,500; Fort Worth drainage basin (Eagle Mountain), 148,500 and 140,800; Wichita drainage basin, 58,280 and 45,530; and Red River drainage basin, 1,988,100 and 2,128,900.

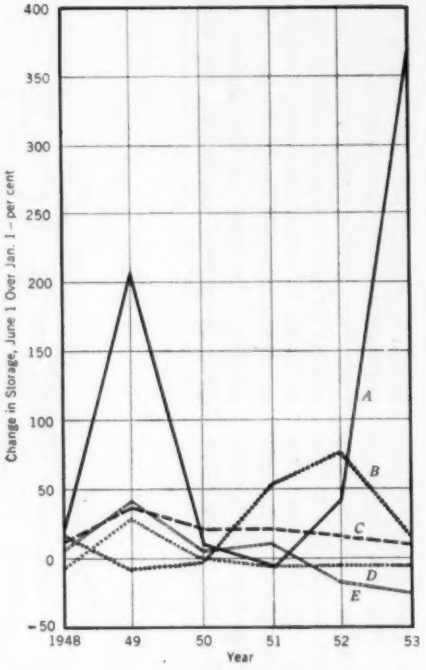


Fig. 5. Percentage Change in Storage, June 1 Over Jan. 1, 1948–53

Lake Dallas figures are compared with those for nearby watersheds: A—*Lake Dallas,* B—*Bridgeport,* C—*Texoma,* D—*Eagle Mountain,* E—*Kemp.*

target area and only 14 in. in the western, the percentage increase in precipitation to the northeast of the project area represents a larger water increase than would a similar percentage to the west.

Operations conducted during the last 10 days of November and the month of December 1952 resulted in an appreciable improvement in soil moisture conditions in the Dallas area. The Erickson Crop Reporting Service stated on Dec. 20, 1952, that the entire Lake Dallas watershed area had a moisture penetration of 25–35 in., as opposed to 10–20 in. in nearby areas to the west. Wheat in the Dallas area was said to be "the best wheat in Texas, both as to surface conditions and moisture." This result must be attributed largely to the Thanksgiving Day storm and the one or two storms that followed it in late November and December. It was these storms, moreover, that prepared the ground for the spring rains, which were almost entirely available to the watershed as runoff. By Apr. 29, 1953, crop observers in the Dallas area were describing winter wheat, alfalfa, rye, and oats as "the most promising crops in years." In its May 1953 bulletin, the Erickson service reported excellent crop prospects for the whole cloud-seeding target area.

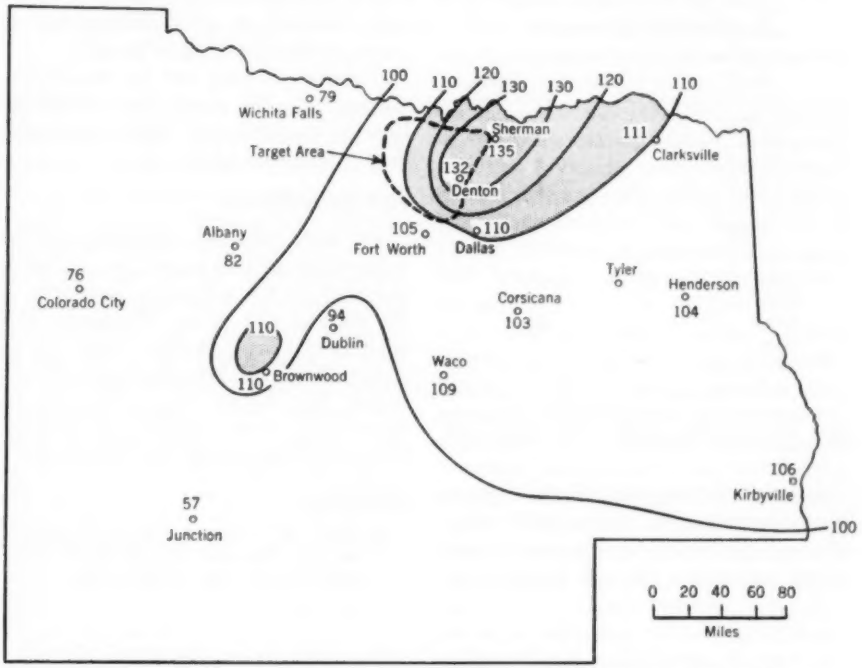


Fig. 6. Percentage Normal Precipitation, Nov. 22, 1952–Apr. 30, 1953

The target area shows higher percentages than the surrounding territory. (The month of May was not included because official figures were not available at the time of writing.)

This is an interesting, independent evaluation of the effects of the operation.

Conclusion

The weight of evidence offered by an increasing number of successful operations of the type described seems to justify confidence in the potential value of cloud seeding and encourages a continued expansion of such projects for both agricultural and water supply purposes.

TABLE 2

*Good Seeding Opportunities**

Month	No. of Good Days
1952	
Nov. 22–30	3
Dec.	1
1953	
Jan.	0
Feb.	2
Mar.	5
Apr.	5
May 1–22	4

* A "good seeding opportunity" may be defined as a major storm situation, in which cloud seeding with silver iodide is most effective.

Research efforts are being directed toward refining operational techniques. Experiments are being made with different types of nucleating agents, in order to insure that the best medium for operations is used at all times and under all conditions. The aim is not only to increase precipitation but to improve the targeting of results.

The desert may not be induced to "blossom as the rose," but substantial benefits to all water users can confidently be anticipated.

Acknowledgment

For their help and suggestions in the preparation of this paper, the author is indebted to the following members of the staff of the Water Resources Development Corp., Denver, Colo.: R. L. Krier, Regional Meteorologist; N. C. Stone, Director of Operations; P. E. Ruch, Vice-Pres.; and E. M. Frisby, Director, Climatology and Research.

Reference

1. Krick, I. P. Increasing Water Resources Through Weather Modification. *Jour. AWWA*, **44**:1009 (Nov. 1952).

Additional-Cost Basis for Fire Service Rates

By Richard H. Ellis

A paper presented on Apr. 6, 1953, at the Canadian Section Meeting, Buffalo, N.Y., by Richard H. Ellis, Hydr. Engr., Factory Mutual Eng. Div., Boston, Mass.

ANY discussion of fire service rates must be predicated on the generally accepted premise that a water works performs not one, but several, distinct functions, including the furnishing of water for: [1] "normal" use, that is, for domestic, commercial, and industrial purposes; and [2] fire protection service. Owing to the nature of the latter function, the water works must be designed to meet fire service requirements during periods of maximum consumption. As the fire service demand may be superimposed on the maximum domestic, commercial, and industrial loads, to meet the total demand will ordinarily require the provision of additional facilities, over and above those needed for normal service.

The fire protection service furnished by a water works is a community benefit as well as a direct service to individual users. Destruction, by fire, of a residence, a business block, or an industrial building results in a loss of taxable properties and, thus, in a loss of revenue to the municipality. Moreover, if it is an industrial structure that has been destroyed, the industry may relocate to another community, thereby causing permanent loss of employment.

Perhaps because water works, in general, are municipally owned and operated and, at least in the United States, are usually outside the control of utility-regulating bodies, rate making has been, to some extent, haphazard and has only infrequently taken into consideration the equity of a proper division of the costs for services rendered water users and taxpayers.

A publicly owned water utility, strictly speaking, is a municipal enterprise rather than a governmental function. It is entirely different from such other civic activities as road construction and maintenance, health and welfare services, supervision of building construction, and operation of school systems. As an enterprise, the water works should be self-supporting and should obtain, through its rate structure, adequate returns to operate, maintain, and develop its facilities so as to offset depreciation and anticipate normal growth.

Although numerous community benefits, such as improvement to public health and enhancement of property values, accrue from the operation of a water works, the worth of such benefits is intangible. The principal functions on which charges can be based are the two previously mentioned: normal service and fire protection service. The costs involved in the performance of these functions must be recovered in the rate structure.

Analysis indicates little or no relationship between water use and potential demand for fire protection. It is easy to realize that the relatively large water use in a small laundry may be entirely disproportionate to its fire demand or that the small use by a lumberyard would not in any way reflect the volume of water required to extinguish a fire there. To be equitable, separate rates should be established for each of these two services and a fair basis developed for the collection of such rates in proportion to the use or benefits received.

It appears logical that the portion of cost allocable to fire protection should be collected from property owners in proportion to the value of the individual properties protected. A suggested method is for the municipality to pay to the water works an amount equal to the cost of providing water for fire protection and to collect the same amount from the public as a part of the tax levy. A method less frequently employed is for the utility to divide the water bill into two parts, one for use and one for fire protection, the latter charge being based on the assessed value of the property. This practice has the advantage of leaving the tax structure of the municipality unaffected.

Some authorities have suggested that the amount charged for fire service should be based on the value of the structures and contents only, as vacant land would receive little or no benefit from this service. This is seldom a major item, however, as the assessments on vacant land are normally low. Furthermore, the availability of this service enhances the property value, so that the fire protection charge may, in this situation, be considered a betterment charge.

Still others have called attention to the apparent inequity of charging the same rate for combustible and noncombustible properties and have suggested that the charge be proportioned on the assessed valuation, multiplied by the insurance rate established for the individual properties. This method would require a complicated accounting system and would involve continuous checking of assessment and insurance records. It might also be pointed out that large structures, although of fire-resistant construction, generally contain combustible contents, a fact that minimizes the importance of this contention to some extent. In the author's opinion, no rate schedule can be perfect in all details. If it is based on sound fundamentals, the simpler it is, the better it is received by the public.

Maximum Fire Requirements

Estimates of the amount of water required for fire protection in communities of various types and sizes are usually based on the standards of the National Board of Fire Underwriters, in the United States, and on those of the Canadian Fire Underwriters Assn., in Canada. From their figures, it becomes apparent that, except, perhaps, in the largest cities, additional facilities are required to meet fire demands superimposed on maximum normal demands.

Almost every study or report on rate making in the last 40 years has recognized the merit of segregating the costs involved in providing normal service and fire protection service and charging proportionately. An early study that has served as a valuable basis for rate making was a 1911 one by Metcalf, Kuichling, and Hawley (*1*). From a compilation of data on numerous complete water works, these writers

calculated the average percentages of distribution system cost and total cost allocated to fire protection. According to this report, the portion of the entire cost of a water works allocable to fire protection will vary from approximately 70 per cent for a community of 5,000 population to 13 per cent for one of 300,000 population.

It should, however, be emphasized that, owing to differences in such factors as supply and distribution storage facilities, average figures cannot be expected to indicate the costs involved in providing normal and fire services at a specific water plant. Therefore, in any study of a particular utility, some method must be developed by which actual costs can be allocated to these two essential services.

Rate-making Methods

The methods adopted for the establishment of rates by public regulatory bodies and by local authorities have varied widely. For municipally owned plants, the interests of the local authorities may be satisfied if the total receipts balance the total expenditures, and the customers are not infrequently called upon to bear the entire capital and operating costs in the rates established for use. This practice is inequitable except where municipally owned plants are relieved of tax payments and such a waiver is considered as offsetting the utility's costs in furnishing community benefits. Even then, the exchange is seldom of equal value. For instance, if the tax value of the utility exceeds the cost of providing fire protection, the property owner stands the loss in his tax payment. On the other hand, where the tax value is less than the utility's fire service costs, the utility has no recourse other than to collect the difference in its rates for water used.

According to a survey made by the Factory Mutual Eng. Div. in 1949 and 1950, it appears that only approximately one-third of the municipally owned systems in the United States actually receive any contributions from the tax levy as reimbursement for fire protection. In Canada, the practice of making a charge against the municipality for such service is more general, and this survey indicated that approximately 65 per cent of the Canadian water utilities are reimbursed for this service to some extent. It may not be out of order, therefore, to assume that as many as 66 per cent of the water utilities in the United States and 35 per cent of those in Canada receive no direct payment for this service from the municipalities.

A review of current rate-making practice indicates that fire protection charges are frequently based on a value per year per hydrant. This appears to be an incorrect premise, as the cost of providing fire protection involves, not hydrants alone, but all facilities contributing to the service. Moreover, the hydrant rental basis has occasionally served as a hindrance to the provision of an adequate number of hydrants, owing to the additional increment of cost to be charged therefor. The entire cost of providing fire protection service should be predicated on interest on investment, depreciation, and operation and maintenance costs of all parts of the property contributing to such service.

Two comprehensive studies, one by a joint committee of the American Society of Civil Engrs. and the Municipal Law Section of the American Bar Assn. and the second by the AWWA rate committee, have been undertaken

within the last few years. The first of these studies has been published (*2*); the AWWA study is still in progress (*3*).

Both committees have considered various methods used in the past to evaluate the proportion of water utility costs allocable to fire protection:

1. To apportion the fire protection costs of an existing plant on the relation that the fixed and operating costs of a system reserved for fire only would bear to the combined costs of separate systems for fire and normal use.

2. To apportion the total fixed costs of the works on the direct ratio of the fire demand to the total demand for fire and normal use and to include only incremental operating costs.

3. To allocate to fire protection only the additional capital and operating costs necessitated by that service.

The third method, although in no way depreciating the importance of fire protection service, assumes that modern living is going to require water service for the enhancement of the health and general business of a community and that the only costs directly allocable to fire protection are those in addition to the cost of providing water for normal service. Such a method is preferred by the joint committee.

Allocation of Charges

The first step to be taken in the establishment of a water rate structure is to determine the present value of the various parts of a water works system. This may be done by estimating the depreciated or replacement value (authorities differ on the base) of the various parts of a water system.

In general, the following grouping of the essential parts of a water system is suggested:

1. Source of supply (including land, rights, dams, intakes, suction piping, and land improvements)
2. Treatment facilities (including sedimentation basins, low-head pumps, filters, clear wells, buildings, and grounds)
3. Distribution piping
4. Distribution storage
5. Pumping plants (including boilers, transformers, electrical appurtenances, pumps, motors, buildings and grounds)
6. Transmission or supply mains from pumping station to distribution system
7. Hydrants
8. Miscellaneous (including supply yard, automotive equipment, and the like)
9. Office and office equipment.

After having established the value of the system, a study should be made of the relative demands created by maximum normal use and the probable maximum requirements for fire protection. Based on the effects of these demands on the various parts of a plant, a proportion of the capital value of these parts can then be assigned to each of the two functions and the annual fixed charges determined by applying a proper interest rate. Operating and maintenance costs should be similarly allocated. The sum of the fixed and operating costs is the amount chargeable to each of two types of service. Certain parts of a water system may be devoted entirely, or almost entirely, to either normal or fire service, whereas other parts may be necessary for the performance of both functions.

Supply and Treatment

In general, only a very small portion, if any, of the fixed and maintenance

costs for source of supply would be chargeable to fire protection. As the source should be sufficiently large to guarantee the required yield over a period of several months—or even years, if extended drought conditions have to be considered—it is self-evident that the volume of water required for fire protection will be only a negligible proportion of the total volume available. Capital investment in source of supply chargeable to fire protection might be limited to the added cost of supplying distribution system leakage (a sum proportional to the fire protection charge against distribution piping) plus the estimated amount used in fire extinguishing (possibly not more than 1.5 per cent of the amount of water delivered to the distribution system).

For treatment facilities, capital and maintenance charges against fire protection are also negligible and are seldom considered. Such facilities are not essential for fire protection. Except in direct-pumping systems and in utilities which have limited distribution storage or where the combination of filter and clear well capacity may be a major item, not more than the same proportion of leakage as is allocated under source of supply may ordinarily be chargeable to fire protection under this heading.

Distribution Piping

The distribution piping will normally bear the greatest proportion of the fire protection charge. In arriving at the proper allocation of charges for this item, it is necessary to determine the relative demands for fire protection and for normal use. At present the most generally accepted formula for establishing the fire demand for municipalities is that of the National Board of Fire Underwriters (NBFU). Although the rate of demand and the volume required for fire protection, as established by this formula, have been exceeded in a number of severe conflagrations, these are exceptional. On the whole, the adequacy of the formula has been proved by the low frequency of fires requiring a greater rate or volume than it indicates.

Using this or any other equally satisfactory formula to calculate the fire demand, the fixed charges for distribution piping can then be allocated in the ratio of fire demand to total demand for fire and normal service. It is usually possible to obtain from station records the rate of normal consumption during average and peak days. When the maximum rate cannot be otherwise determined, it is customary to assume it to be 150 per cent of the average day rate.

For instance, in a city of 100,000 population having a maximum consumption of 17 mgd (11,800 gpm) the fire demand, according to the NBFU formula, would be 9,000 gpm. The combined demand for fire and normal use would, therefore, equal 20,800 gpm, and the proportion of the capacity of the distribution mains chargeable to fire protection would be $9{,}000 \div 20{,}800 = 43.25$ per cent.

In a community of 20,000 having a maximum demand of 1.95 mgd (1,350 gpm) for normal use, the fire demand would be established as 4,500 gpm. Therefore, the proportion of distribution main capacity chargeable to fire protection would be $4{,}500 \div 5{,}850 = 77$ per cent.

In allocating the fixed distribution system costs chargeable to fire protection, it is customary to exclude 4-in., and occasionally 6-in., mains, as these

sizes furnish only a limited volume for fire and their capacity would normally be required for general service. Any deficiency in the ability to deliver the desired amount of water for fire protection to the congested business and industrial districts should be noted, and the amount allocated to fire service should be reduced proportionately.

The percentage of distribution system capacity chargeable to fire protection will, of course, vary with the maximum normal demand. Caution should be used in applying the NBFU formula, which is based on the population of cities and towns having average commercial and industrial developments. For a specific city, any marked deviation from the average should be recognized by adjusting the fire requirement so that it will at least approach that required in an average community (of greater or smaller population) having a similar concentration of commercial or industrial buildings.

Distribution system maintenance and repair costs can normally be allocated in the same proportion as capital costs.

Pumping and Storage

Distribution reservoirs, pumps and auxiliary equipment should be of sufficient capacity to deliver, during a 5-day period of maximum consumption, the maximum normal fire service demands for a 4–10-hr period (depending upon the size of the community) with one or two pumps out of service. Except in direct-pumping systems with no distribution storage, the peak demand created by maximum consumption plus fire load will ordinarily be supplied partly by pumps and partly from distribution storage. Therefore, to allocate to fire protection the proper proportion of the capital investment in pumping facilities and distribution storage, these two elements of a water works should be considered together.

The NBFU basis for evaluating the relative adequacy of a water system can be used to determine the deficiency of the combined pumps and storage in supplying the total demand for all purposes, and to allocate the proper proportion of capital investment in these facilities to fire and normal service. Utilizing the appropriate NBFU formula and deficiency scale (see Appendix), the number of deficiency points is found with first the largest and then the two largest pumps out of service. The sum of these two figures is divided by 250 (the maximum number of deficiency points allowed for pump capacity), giving the deficiency factor. The percentage of cost that would be allocable to fire service if no deficiency existed is determined in the same way as for distribution piping. Multiplying that percentage by the complement of the deficiency factor yields the percentage of investment in pumping and distribution storage allocable to fire service.

For systems with no pumping or storage deficiency, the deficiency factor is, of course, omitted. In that event, care should be taken to allocate a proper proportion of the cost of standby equipment to fire service.

Other Items

The capacity of the transmission mains and the yield from distribution storage should be considered together. Only that proportion of main capacity needed to furnish the excess required for fire should be charged to fire protection.

All costs incidental to the installation and maintenance of hydrants and

hydrant connections should be charged against fire protection.

In addition to the foregoing there are other incidental accounts, such as shop buildings and pipe yards, all of which may be used for both fire protection and normal service. Although the allocation of charges for these items against fire protection would be small —as would be the charges for supervision, maintenance labor, office expense, and overhead—such allocations would not be illogical, particularly if fire protection service may require extra shop labor or office expense.

Conclusion

The collection of a proper amount for fire protection service, either by way of taxes or by a charge against property owners in proportion to the value of their properties, permits the establishment of a rate schedule that is equitable for the water customers. If the fire service reimbursement is obtained through a contribution from the tax levy, it naturally follows that the municipality is entitled to collect taxes from the utility, based on a reasonable valuation of the water works properties. Thus, both customers and taxpayers benefit from properly established fire service rates.

References

1. Metcalf, L.; Kuichling, E.; & Hawley, W. C. Some Fundamental Considerations in the Determination of a Reasonable Return for Public Fire Hydrant Service. *Proc. AWWA*, p. 55 (1911).
2. Joint Committee Report. Fundamental Considerations in Rates and Rate Structures for Water and Sewage Works. *Ohio State Law J.*, p. 151 (Spring 1951).
3. Committee Progress Report. Water Rates. *Jour. AWWA*, **43**:665 (Sept. 1951).
4. *Standard Schedule for Grading Cities and Towns of the United States.* National Board of Fire Underwriters, New York (1942); *Jour. AWWA*, **34**: *following p.* 1584 (Oct. 1942).

APPENDIX

Determination of Pumping and Storage Cost Allocable to Fire Service

1. Given the following: population, 40,000; maximum normal consumption (M), 4,160 gpm (6.0 mgd); fire demand (F), 6,000 gpm (8.65 mgd); distribution storage capacity (S), 2.0 mil gal; pump capacity, two at 2,000 gpm (2.87 mgd) each and three at 1,500 gpm (2.13 mgd) each; pump capacity with largest pump out of service (Q_1), 9.26 mgd; pump capacity with two largest pumps out of service (Q_2), 6.4 mgd; R*, 2.4.

2. Select the deficiency (D) formula for the appropriate condition (storage in mil gal, other values in mgd):

* R is a factor based on required duration of fire flow: for 4 hr, $R = 6$; 5 hr, 4.8; 6 hr, 4; 7 hr, 3.4. 8 hr, 3; 9 hr, 2.7; 10 hr, 2.4.

a. No storage:

$$D = \frac{M + F - Q}{M + F}$$

b. Pump capacity greater than maximum normal consumption and with storage:

$$D = \frac{M + F - Q - SR}{M + F}$$

c. Pump capacity less than maximum consumption, with storage less than five times the difference:

$$D = \frac{M + F - Q - 0.2S}{M + F}$$

TABLE 1

*Deficiency Point Scale, Corresponding to Calculated Percentages**

Units	Tens										
	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
0%	0	10	25	45	67	90	112	134	156	178	200
1%	1	12	27	47	70	92	114	136	158	180	
2%	2	13	29	50	72	94	116	138	160	182	
3%	3	15	31	52	74	97	119	141	163	185	
4%	4	16	33	54	77	99	121	143	165	187	
5%	5	18	35	57	79	101	123	145	167	189	
6%	6	19	37	59	81	103	125	147	169	191	
7%	7	21	39	61	83	105	127	149	171	194	
8%	8	22	41	63	85	108	130	152	174	196	
9%	9	24	43	65	88	110	132	154	176	198	

* In rating pump and distribution storage deficiencies, charge the full number of points for any deficiency resulting from one pump out of service plus one-fourth of the points for a second pump out of service. Table taken from *Standard Schedule for Grading Cities and Towns of the United States* (4).

d. Pump capacity less than maximum consumption, with storage more than five times the difference:

$$D = \frac{F - SR - 5(M - Q)}{M + F}$$

In this example, formula *b* applies:

$$D_1 = \frac{M + F - Q_1 - SR}{M + F}$$

$$= \frac{6.0 + 8.65 - 9.26 - (2.0 \times 2.4)}{6.0 + 8.65}$$

$$= 0.0403 = 4.0\%$$

$$D_2 = \frac{M + F - Q_2 - SR}{M + F}$$

$$= \frac{6.0 + 8.65 - 6.4 - (2.0 \times 2.4)}{6.0 + 8.65}$$

$$= 0.236 = 23.6\%$$

3. Using the NBFU scale (Table 1), find the number of deficiency points represented by the percentages calculated above. For D_1, use full deficiency scale value: for D_2, use one-fourth of scale value:

$$D_1 = 4 \text{ points}$$

$$D_2 = \frac{32}{4} = 8 \text{ points}$$

Total deficiency = 12 points

$$\text{Deficiency factor} = \frac{12}{250} = 0.048$$

4. Calculate the proportion chargeable to fire service if no deficiency exists:

$$\frac{F}{M + F} = \frac{8.65}{14.65} = 0.59 = 59\%$$

5. Multiplying by the complement of the deficiency factor:

$$59(1.0 - 0.048) = 56.2$$

The percentage of investment chargeable to fire service is, therefore, 56.2.

Effect of Irrigation Runoff on Surface Water Supplies

Panel Discussion

A panel discussion presented on May 14, 1953, at the Annual Conference, Grand Rapids, Mich.

Morrison B. Cunningham

Supt. and Engr., Oklahoma City Water Dept., Oklahoma City, Okla.

THE highest-priority use of water is for municipal purposes. Without an adequate municipal supply properly safeguarded against pollution, urban life cannot prosper. In planning and developing water resources, full consideration must be given to pollution abatement, rising per capita use, and increasing industrial demand. The time has come when studies on the use of water for irrigation must include the effect of irrigation runoff on surface and ground water supplies downstream from the land to be irrigated.

The author's attention was first called to this problem in 1951, when federal agencies filed a report on the proposed Canton, Okla., irrigation project, located approximately 30 miles above the Oklahoma City municipal water supply reservoirs. Investigation by Oklahoma City showed that the increase in minerals—particularly chlorides—in the irrigation runoff water would seriously affect the municipal source of supply. The applied water would amount to 30,000 acre-ft annually, one-third of which would return to the river. It was reported that the mineral concentration in the return flow would be at least three times as great as in the applied water, total hardness increasing from 300 to 900 ppm and chlorides from 130 to 390 ppm. Much greater increases might occur. For example, U.S. Dept. of Agriculture studies on the Rio Grande indicate that the concentration of chlorides below Fort Quitman Reservoir is thirteen to fifteen times as high as upstream.

The return flow from the Canton irrigation project would enter the North Canadian River, a stream that serves as an intermittent source of supply for Oklahoma City. It is not uncommon for the river to be dry for months at a time. It is estimated that two flood control reservoirs which are located above the proposed project would have to provide a minimum of 40,000 acre-ft a year to dilute the irrigation return flow sufficiently to render the water usable for municipal purposes.

Much more information is needed on the effects of return flow on water quality, to enable this factor to be evaluated in advance of the construction of an irrigation project. In planning the utilization of water resources for one purpose—whether for municipal or industrial supply, flood control, or irrigation—consideration must be given to the effects of proposed construction on other possible uses. Unless comprehensive studies are made

with the cooperation of the different interests, municipal quality and quantity requirements are likely to be ignored in project planning. Discussions like the present one, which air the views of municipal water utilities, help to encourage the trend toward more coordination in the overall development of the nation's water resources.

Pollution abatement becomes a most difficult problem in a stream with a small or intermittent flow. This is true whether effluent from a modern sewage treatment plant, return water from irrigation, or some other source of pollution is involved. Multiple-purpose reservoirs are desirable if full attention is paid to balanced utilization of water, taking care to insure the adequacy and to safeguard the quality of present and future municipal supplies.

It appears urgent to adopt the following courses of action:

1. Develop more studies on irrigation runoff water from projects now in operation.
2. Do more research to determine, in advance of construction, the quality of irrigation runoff.
3. Include in engineering studies of irrigation projects a full and complete report on the effect return flow will have on municipal water supplies located downstream.
4. Encourage unified planning for optimum use of water resources.

Paul D. Haney and Thomas W. Bendixen

Respectively, San. Engr. Director and Soil Scientist, Environmental Health Center, U.S. Public Health Service, Cincinnati, Ohio.

There are approximately 26,000,000 acres of irrigated land in the United States, the bulk of which is located in the seventeen states west of the ninety-fifth meridian. These states comprise approximately 60 per cent of the area of the nation (*1*). Agriculture throughout much of this vast region must be supported by irrigation. In 1890 only 4,000,000 acres of western land were under irrigation (*2*), but this acreage more than quadrupled during the next 30 years. Since 1920 acreage under irrigation has increased at a much slower rate. Future growth will be determined by the availability of water at a price commensurate with the benefits derived from its use for irrigation.

Only approximately 1,500,000 acres (*3*) are now under irrigation in the eastern states. A certain amount of irrigation in the humid eastern areas is advantageous because crop failures can be prevented during dry years and higher yields can be obtained during normal years. The outlook is for increased use of water for irrigation in the East (*2*).

For the entire nation, irrigation leads all other water uses by a considerable margin. Sources and estimated use of fresh water in the United States in 1950 (*4, 5*) are shown in Table 1. Total water resources use has roughly quadrupled within the past 50 years (*4*).

Table 2 indicates the approximate extent of water use for various purposes in the eastern and western regions of the United States (*4*). The present irrigation use in the West is on the order of 90,000 mgd. One estimate (*4*) puts the amount for irrigation in 1975 at approximately 110,000 mgd.

Consumptive Use of Water

Of the total water withdrawn for rural, municipal, industrial, and irrigation use, probably 60 per cent is returned to natural drainage and is available for reuse. The bulk of this return is from industries and municipalities.

A substantial portion of the water used for irrigation is consumed by evaporation and transpiration. Applied to irrigation agriculture, the term "consumptive use" is equivalent to "evapotranspiration," defined as "the quantity of water transpired by plants during their growth or retained in the plant tissue plus the moisture evaporated from the surface of the soil and the vegetation, expressed in feet or inches depth of water lost or used in a specified time" (*6, 7*). Consumptive use accounts for roughly two-thirds of all the irrigation water used. The remaining third generally finds its way back to the stream channel from which it was diverted and is frequently referred to as "return flow." Part of this return flow reaches the stream through surface runoff and part through underground seepage. Estimated consumptive water use (*4*) as of 1950, on a regional basis, is shown in Table 3.

TABLE 1

Source and Use of Water
(United States, 1950)

Use	Wells	Streams and Lakes	Total	Per Cent of Total Use
	1,000-mgd units			
Rural	2.8	0.7	3.5	2
Municipal	3.5	10.0	13.5	8
Industrial	6.0	59.0	65.0	38
Irrigation	18.0	70.0	88.0	52
Total	30.3	139.7	170.0	100

The amount of water withdrawn for irrigation varies widely, ranging from less than 2 to more than 10 acre-ft per acre per year (*2*). Not all of this water is available for crop production, as there is a significant loss in getting it to the fields. Part of this loss is due to seepage from the conveyance ditches and canals, while some results from evaporation from water surfaces and transpiration by weed growths along the ditches. From 20 to 60 per cent of the water diverted may reappear as return flow, although, as previously stated, a general average value for return flow is approximately 33 per cent.

Salt Balance

Maintenance of a favorable salt balance is an important aspect of irrigation practice. According to Houk (*2*), the salt balance of an irrigated area may be defined as the difference between the total dissolved solids brought to the land annually by the irrigation water and the total solids carried away annually by the drainage water. When the input of mineral salts is less than the output, the salt balance is favorable. When the input is significantly greater than the output, undesirable salts probably accumulate around the roots. Conditions within the root zones determine the agricultural suitability of the land (*2*).

TABLE 2

Approximate Regional Use, 1950

Use	Per Cent of Western Total*	Per Cent of Eastern Total†
Domestic	5	16
Private industrial	3	81
Irrigation	92	3
Total	100	100

* Total western withdrawal (17 states), 95,000 mgd.
† Total eastern withdrawal (31 states), 75,000 mgd.

The object of irrigation project drainage is to remove not only surplus water but also as much harmful mineral matter as is brought in by the water applied to the land (*8*).

Some studies (*9*) indicate that at least 10 per cent of the water added to the soil should go on through as drainage water to leach salts. This

figure must be raised as the quality of the irrigation water decreases and as the clay content of the soil increases, in order to control the salt balance.

The Rubidoux Laboratory of the U.S. Dept. of Agriculture made tests on the growth of alfalfa. Irrigation water containing a rather high total salt concentration (approximately 1,000 ppm) was applied to the alfalfa, and the percolate was measured and analyzed. The conclusions of this study, as given by Houk (*2*), were: [1] it was necessary to use 22.5 per cent of the input water for leaching in order to prevent accumulation of salts in the root zones; [2] the alfalfa and soil absorbed approximately 14 per cent of the salts in the irrigation water; and [3] approximately 800 lb of water was evaporated and transpired for each pound of dry alfalfa produced.

TABLE 3

Estimated Total and Consumptive Use, 1950

Item	17 Western States*		31 Eastern States†	
	1,000 mgd	*gpcd*	*1,000 mgd*	*gpcd*
Fresh-water withdrawal	95	2,700	75	650
Consumptive use	60	1,700	7	60

* Population 34,400,000.
† Population 117,400,000.

Illustrations of the trend of salt balance conditions for three irrigated valleys have been reported by Scofield (*10*). Two of the areas are along the Rio Grande, in the vicinity of El Paso, Tex., and the third is along the Colorado River, near Yuma, Ariz. The volume and salt constituents of the irrigation water input and the drainage water output were measured in each area. A portion of Scofield's data is shown in Table 4. Only the Mesilla Valley had a favorable total-salt balance. Certain salts were accumulating in the soils of the other two valleys, which had unfavorable salt balances. In all three areas, however, the concentration of salts in the output waters was higher by at least 50 per cent than in the input waters.

Water Quality Data

Repetition of the process of withdrawal for irrigation use, evapotranspiration, and return to natural drainage of a portion of the water can result in a gradually increasing concentration of dissolved mineral matter in the streams receiving drainage from irrigated land. Streams generally show a progressive increase in dissolved mineral concentration between headwaters and mouth (*11*). Diversion of water for irrigation use, followed by return of only a portion containing much of the water's original mineral load plus additional salts leached from the soil, may, however, markedly increase this natural trend. This fact was noted more than 50 years ago by Headden (*12*), who studied the Cache la Poudre River and other streams in Colorado.

The Cache la Poudre River rises in the mountains of northern Colorado and flows generally southeastward, joining the South Platte River near Greeley, Colo. It has a drainage area of approximately 1,840 sq miles, 1,050 of which are tributary to the Fort Collins gage, located approximately 50 miles from the mouth of the Cache la Poudre. The average annual discharge at this point is 409 cfs (*13*). At the gage located 2.5 miles from the mouth, the average annual discharge is only 93.4 cfs (*13*). This large decrease in

annual discharge in the face of an increase in catchment area indicates the extensive consumptive use of the waters of the Poudre. Approximately 250,000 acres of land were under irrigation in the Poudre watershed in 1944. Irrigation water use in 1944 was reported to be 332,900 acre-ft. The length of the main stem is approximately 120 miles. Major main-stem irrigation diversions begin at a point approximately 50 miles from the mouth of the Poudre (*14*).

Headden's analyses (*12*), published in 1903, showed a large increase in dissolved solids in a 50-mile reach. At a point approximately 55 miles from the mouth, the stream had a total-dissolved-solids content of 37 ppm. At a point 2 miles above Greeley, which is approximately 7 miles from the mouth, the solids content had increased to 1,571 ppm.

Data on quality changes computed from Clarke's report (*11*) of Headden's analyses are presented in Table 5.

TABLE 4

Salt Balance in Some Irrigated Valleys

Item	Mesilla Valley (N.M.–Tex.)	El Paso Valley (Tex.)	Yuma Valley (Ariz.)
Irrigated area—*acres*	80,000	60,000	40,000
Irrigation water—*acre-ft*	744,380	496,113	259,917
Drainage water—*acre-ft*	496,113	173,219	57,095
Per cent of irrigation water	66.6	34.9	22.0
Salts in irrigation water:			
tons/acre-ft	0.805	1.226	0.956
*ppm**	592	900	704
Salts in drainage water:			
tons/acre-ft	1.226	2.666	1.993
*ppm**	900	1,970	1,470
Output of salts—*per cent of input*	101.5	75.9	45.8
Output salt concentration—*per cent of input*	152	218	208

* Author's calculations.

Clarke (*11*), referring to Headden's earlier work (*12*), describes the changes in the Poudre River: "The Cache la Poudre River in Colorado flows first through a rocky canyon over boulders of schist and granite and thence emerges upon the plains. Its waters are then diverted into ditches and reservoirs for purposes of irrigation and finally reach the Platte near Greeley. In performing the work of irrigation they acquire a new load of solid matter and the progressive changes in their composition are clearly shown by Headden's analyses."

It is apparent that the waters of the Poudre gained a considerable load of solid matter and that the percentage composition of the dissolved mineral matter was altered to a marked extent. Clarke indicated that this change was due in part to the use of the water for irrigating an originally arid soil containing much soluble matter, and that thorough leaching probably would result in less exaggerated changes. Irrigation started in the Poudre Valley long before 1902 and has been actively practiced ever since. Limited information comparable to the 1902 data was

collected in connection with a water pollution survey (*14*) on the Poudre during 1948 and 1949. The 1949 data (Table 6) show that quality changes of the order found by Headden in 1902 persisted nearly a half century later. Similar changes were noted in the quality of the South Platte River, which receives irrigation return flow from approximately 1,250,000 acres (*14*).

Banks and Lawrence (*15*) have discussed the influence of irrigation drainage on water quality in the San Joaquin River in California. They define "degradation" as "an impairment to quality caused by the development, use, and reuse of the water itself" and cite one cause of such impairment as the inflow of irrigation drainage. Such drainage water, they state, may contain 4,000 ppm or more of total dissolved solids and can cause a marked change in the composition of the receiving waters, generally an increase in the proportion of sodium salts. Total solids in the San Joaquin River were increased more than fifteen-fold in a river reach of 85 miles (34 ppm to 570 ppm). There was an increase of more than 40-fold in chloride in this same reach (3.8 ppm to 170 ppm).

TABLE 5

Poudre River Quality Changes, 1902

Item	Distance From Mouth—*miles*	
	55	9
Approximate flow—*cfs*	*	24†
Date sampled	Nov. 3	Aug. 11
Total hardness—*ppm*	18	920
Alkalinity as $CaCO_3$—*ppm*	20	190
Noncarbonate hardness—*ppm*	0	730
Sulfate as SO_4^{--}—*ppm*	3.4	940
Chloride as Cl^-—*ppm*	1.5	40
Total dissolved solids—*ppm*	37	1,571

* Sample "was taken at a time when there was no flood water and after a period of good weather . . . . The water then flowing represented the normal water of the Poudre" (*12*).

† Flow on July 27, 1902, at or near sampling station (*12*).

Thorne's (*9*) investigation of the Sevier River in Utah showed progressive mineralization in this stream, owing mainly to irrigation return flow. Increasing mineralization is said to have created an irrigation water quality problem in the lower portion of the Sevier River drainage area (*9*).

Data illustrating the effects of irrigation diversions and drainage returns on the composition and concentration of the waters of the Rio Grande have been presented by Wilcox (*16*). Water quality data computed from analytical results given by Wilcox are shown in Table 7. These results cover the river reach from Santa Fe, N.M., to a point approximately 80 miles below El Paso, Tex. Irrigation projects are found all along the river, except in the Elephant Butte Reservoir section (San Marcial to Caballo Dam). The values given are weighted (according to flow) means of monthly composite samples for 1945. The dissolved-solids data in Table 7 are of the same order of magnitude as the mean values given by Lowry (*17*) for the period 1931–49 at Caballo Dam, El Paso, and Fort Quitman. It is evident that, as the total flow decreases because of consumptive use, the concentration of mineral matter increases, its composition changes, and the water becomes less satisfactory for further use, including irrigation, as it proceeds downstream.

In discussing southwestern water problems in 1938, Lippincott (*18*)

summarized the quality changes in the Rio Grande thus:

The increase in salinity of the waters of the Rio Grande due to their use and reuse in its long drainage basin is of interest. The river rises in high granitic mountains in Colorado where the salinity of the water is low, amounting to 110 ppm (0.15 ton per acre-foot of water) at Del Norte, Colo. Tributaries enter along its course. At the Colorado–New Mexican boundary line the salt content has increased to 206 ppm. After the water is used near Albuquerque and as it enters the Elephant Butte Reservoir, this salinity has increased to 427 ppm. At El Paso it has become 832 ppm, equal to 1.13 tons per acre-foot, and at the lower end of the El Paso Valley at Fort Quitman, it is 2,120 ppm or 2.88 tons per acre-foot. This increase in salinity with the irrigation use of water in the upper basin of the Rio Grande is interesting when considered in connection with the prospective greater irrigation use of the Colorado River in its upper drainage basin.

At comparable stations, dissolved-solids concentrations given by Lippincott check closely with the values contained in Table 7 and the average values (1931–49) given by Lowry (17).

In the Arkansas River Valley in Colorado, irrigation has reached a high state of development. Normal stream flows in the summer are used entirely for irrigation. There are 23 major irrigation diversions between a point approximately 50 miles above Pueblo and the Colorado-Kansas line. Return flows in excess of 200,000 acre-ft annually reach the river channel between Pueblo and Holly. Approximately 500,000 acres are irrigated annually in the Colorado portion of the Arkansas Basin (*19*).

Percentage composition as well as concentration changes are illustrated by U.S. Bureau of Reclamation data on the Arkansas River between Pueblo and Holly (*20*). Water quality data for the water year 1940–41 are presented in Table 8 and are shown graphically in Fig. 1.

TABLE 6

Poudre River Quality Changes, 1949

Item	Distance From Mouth—*miles*			
	50	50	14	14
Flow—*cfs*	32	32	45	45
Date sampled	June 15	June 20	Aug. 26	Sept. 13
Total hardness—*ppm*	25	17	816	918
Total alkalinity as $CaCO_3$—*ppm*	28	22	258	286
Noncarbonate hardness—*ppm*	0	0	558	632

Headden's analytical results on Arkansas River samples collected in 1898 and 1903 showed generally similar dissolved-solids changes in the river reach from Canon City to Rocky Ford, Colo. (*12*). Canon City is roughly 50 miles upstream from Pueblo, and Rocky Ford is approximately 70 miles below it.

Effects of Return Flow

Considerable variation in the effects of irrigation return flow on water quality is to be expected. The factors in-

volved include: size of irrigated areas, number of times water is used, properties of soils, age of irrigation project, nature of aquifers, rainfall, dilution, temperature, irrigation practices, and storage reservoirs. It is, therefore, very difficult to generalize, except in a rough qualitative way, about the effects of return flow on receiving-water quality. Some general trends may, however, be predicted from observing what happens when irrigation water is applied to land. Little of the total mineral content of the water is taken up by the plants (*8*). Consequently, as evaporation and transpiration occur, there is an appreciable concentration of salts. Most of the original mineral matter is then contained in a much smaller volume of return flow. Repeated salt concentration by evaporation and transpiration, together with leaching of arid soils, which usually contain more soluble matter than soils in humid regions, can result in considerable mineral gain in receiving streams. The general tendency in a stream, as the water is used and reused for irrigation, is in the direction of a significant increase in total dissolved mineral solids, with attendant increments in hardness, chloride, and sulfate content. The nitrate content may not increase greatly, probably because nitrate is in demand as a plant food.

It is evident that, with the increase in salt concentration, some important changes also occur in the percentage composition of the dissolved solids. The trend will usually show a percentage decrease in calcium, accompanied by an increase in sodium. Changes in the proportion of magnesium may not be so great, but, as with other ions, the actual concentration will usually

TABLE 7

Weighted Mean Concentrations, Rio Grande, 1945

Item	Downstream →							
	Otowi Bridge*	San Marcial†	Elephant Butte‡	Caballo Dam	Leasburg Dam	El Paso	County Line§	Fort Quitman‖
Total discharge—*acre-ft*	1,131,550	813,750	839,690	882,920	814,170	568,900	280,620	207,710
Electrical conductivity [EC × 10^6 at 25°C]	280	567	662	740	778	1,210	2,880	3,200
Sodium—*per cent*#	24	41	42	43	44	51	60	62
Boron (B)—*ppm*	0.03	0.10	0.11	0.11	0.12	0.18	0.32	0.33
Dissolved solids—*ppm*	190	380	430	480	510	802	1,870	2,060
Calcium (as Ca^{++})—*ppm*	33.5	51.4	58.1	62.8	64.8	89.4	173	175
Magnesium (as Mg^{++})—*ppm*	6.0	9.7	12	13.1	13.7	18.8	36.0	44.6
Total hardness (as $CaCO_3$)—*ppm*	108	168	194	210	218	300	579	620
Alkalinity (CO_3^{--}+HCO_3^-) as $CaCO_3$—*ppm*	86	124	133	144	142	190	220	206
Carbonate hardness (as $CaCO_3$)—*ppm*	86	124	133	144	142	190	220	206
Noncarbonate hardness (as $CaCO_3$) —*ppm*	22	44	61	66	76	110	359	414
Sodium (as Na^+)—*ppm*	16	52.9	63.5	73.6	78.9	146	407	461
Sulfate (as SO_4^{--})—*ppm*	47	112	149	156	169	254	457	497
Chloride (as Cl^-)—*ppm*	5	32	35	50	54	122	554	644
Nitrate (as NO_3^-)—*ppm*	trace	1	trace	0.6	0.6	0.6	1	0.6

* Near Santa Fe, N.M.
† Upper end of Elephant Butte Reservoir.
‡ Reservoir outlet.
§ Hudspeth County, Tex.
‖ Approximately 80 miles below International Dam at El Paso.
100 Na/(Na + K + Ca + Mg); concentrations in equivalents per million.

show a marked increase. On a percentage basis, bicarbonate will generally decrease, but sulfate and chloride may increase substantially.

Reduction in the proportion of calcium in the dissolved mineral matter probably results from precipitation of calcium carbonate in the soil and ion-exchange action by the soil. In consequence, there is an increase in the proportion of sodium in the dissolved mineral matter, an undesirable change from the standpoint of further irrigation use. Sodium, like calcium, will react with ion-exchange materials in the soil. If sodium is the predominant cation in an irrigation water, undesirable changes will take place in the soil, rendering it less permeable, difficult to work, and generally unsuited to crop production. The adverse effects of high-sodium waters have been summarized in the saying, "Hard water makes soft land and soft water makes hard land" (*16*).

In addition to its percentage sodium content, irrigation water quality is judged on the basis of total dissolved salts or electrical conductivity, as well as boron content (*16*). The maximum concentrations that can be tolerated are approximately 1,500 ppm dissolved solids and 1–3 ppm boron; substantially lower concentrations are, of course, desirable.

Mineralized irrigation percolate has been termed "irrigation sewage" (*21*).

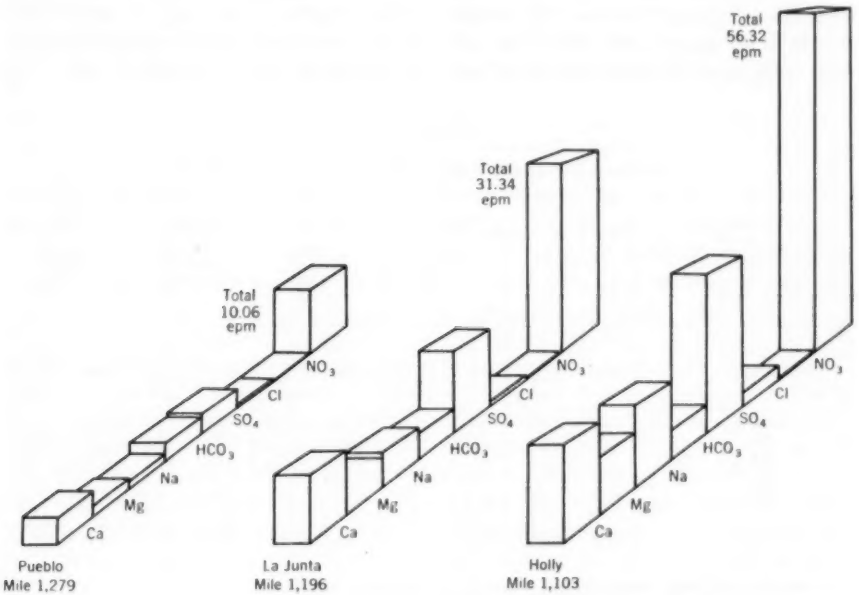


Fig. 1. Arkansas River Mean Water Quality

Mean concentrations in equivalents per million (epm) are shown for the water year 1940–41. The mileage figures indicate approximate distance from mouth of river.

The problem of dealing with this residual salt load has been recognized as one of the phases of irrigation practice about which more information is needed (*8*).

Irrigation agriculture may be thought of as a process industry in which water plays a major role, as is generally true in such industries. The water thus used may become so laden with the irrigation process salt wastes that it is no longer well suited for further irrigation or other beneficial use. works profession is not alone in its interest in water quality. Irrigation farmers are certainly affected by it, too. Irrigation water quality requirements are just as exacting, in some respects, as are those for public water supply or industrial use.

Dilution of a mineralized water with one of low mineral content is a means of maintaining reasonably satisfactory water quality. One way in which dilution water may be made available is by a reduction in consumptive use. Although consumptive use of water by the crops themselves cannot be decreased without lowering crop yields (*22*), and the tendency is in the direction of higher yields per acre, a decrease in the water used by nonbeneficial vegetation probably presents one of the best opportunities for saving water. For example, salt cedars in the West are estimated to consume on the order of 20,000 mgd (*4*). Improved efficiency in the conveyance and application of irrigation water also of-

TABLE 8

Arkansas River Mean Water Quality, Water Year 1940–41

Gaging Station	Pueblo		Nepesta		La Junta		Caddoa		Holly	
Distance from mouth—*miles*	1,279		1,247		1,196		1,154		1,103	
Discharge—*acre-ft*	503,200		567,800		107,600		309,900		169,000	
Total dissolved solids—*ppm*	346		542		1,088		1,376		2,034	
Sodium—*per cent**	16		21		27		34		37	
Ion	*epm*	Per Cent of Total epm	*epm*	Per Cent of Total epm	*epm*	Per Cent of Total epm	*epm*	Per Cent of Total epm	*epm*	Per Cent of Total epm
Ca^{++}	2.97	29.5	4.60	27.7	7.70	24.6	8.51	20.8	10.87	19.3
Mg^{++}	1.26	12.5	1.95	11.8	3.67	11.7	5.00	12.3	6.81	12.1
Na^{+}	0.80	8.0	1.75	10.5	4.30	13.7	6.88	16.8	10.48	18.6
HCO_3^{-}	2.25	22.4	2.71	16.3	3.40	10.8	3.20	7.9	3.98	7.0
SO_4^{--}	2.54	25.2	5.19	31.3	11.48	36.7	16.15	39.6	21.89	38.9
Cl^{-}	0.20	2.0	0.33	2.0	0.75	2.3	1.01	2.5	2.22	4.0
NO_3^{-}	0.04	0.4	0.07	0.4	0.04	0.2	0.03	0.1	0.07	0.1
Total	10.06	100.0	16.60	100.0	31.34	100.0	40.78	100.0	56.32	100.0

* 100 Na/(Ca + Mg + Na); concentrations in equivalents per million.

Disposal of the burden of residual salts from irrigation projects in such a way that the receiving-water quality will not be unreasonably impaired is one of the many problems associated with the multiple use of water resources. Probably there will be more concern with this matter in the future than there has been in the past. The country is growing steadily and the water quality, as well as quantity, needs of cities, farms, and industries will have to receive increasingly careful study. The water

fers an opportunity for saving water (*22*).

Phosphorus Content

Of the three major plant-food elements—potassium, nitrogen, and phosphorus—the last is perhaps of most interest to those responsible for water works operation. Nitrogen, phosphorus, potassium, and probably many other elements are important in algal production. For many blue-green forms, however, phosphorus seems to be the key limiting element in the fertilization of lakes and impounding reservoirs. Sawyer has indicated that potassium is normally in adequate supply and that deficiency in nitrogen can be overcome by fixation from the atmosphere (*23, 24*). Control of the amount of phosphorus entering lakes is a problem of increasing concern. Sawyer has suggested 0.01 ppm as a limiting concentration for inorganic phosphorus, based on his observations at numerous Wisconsin lakes. This amount was believed to be the approximate level of phosphorus that could be tolerated in the Wisconsin lakes without supporting undesirable algal growths.

Major sources of phosphorus in surface waters are sewage and drainage from agricultural land. Rudolfs' studies on the quantity of phosphorus in sewage indicated phosphorus ranges of approximately 0.5–1.2 lb per capita per year (*25*). Sawyer (*23*) reported 1.2 lb per capita per year at Madison, Wis., during a 2-year survey (1942–44).

The phosphate content of sewage has been increasing in recent years, with the growing use of detergents containing various phosphate compounds. The consumption of phosphates in the detergent and water-softening field is now approximately 2.5 times that of 1941. The total consumption of phosphates in the detergent and water-softening industries during 1950 was 535,000 tons, or approximately 6.7 lb per capita per year. The average phosphorus content of these chemicals was approximately 23.4 per cent, equivalent to 1.57 lb of phosphorus per capita per year.

In connection with his Wisconsin lake studies, Sawyer (*24*) investigated the contributions of lake-fertilizing matter from agricultural areas. His results indicated that agricultural runoff plus seepage in the Madison area contributed approximately 255 lb of phosphorus per square mile of drainage area per year. Biologically treated sewage was found to supply approximately 1.2 lb of phosphorus per capita per year. Sawyer concluded that, on a phosphorus basis, the population equivalent of drainage from 1 sq mile of agricultural land is 212 persons.

Probably an average figure of 255 lb of phosphorus per year per square mile of drainage area is high for irrigated western land, where rainfall and runoff are low. For any great quantity of phosphate to appear in irrigation return waters, the phosphate would have to escape fixation by the growing crops and precipitation in the soil. Nitrates do not seem to be a serious problem in streams receiving irrigation drainage, and probably wasteful quantities of phosphate fertilizer would have to be applied to irrigated land in order to contribute major quantities of phosphate to surface waters. More data are needed on the phosphate content of irrigation return waters, however, before a definite conclusion can be reached. It seems fairly certain that, whatever the magnitude of the phos-

phorus problem is or may become, it is not limited to irrigated areas. Fertilizer and detergent sales are on the increase all over the country. Sewage and runoff from unirrigated land have already been shown to be important sources of "available" phosphorus.

Insecticides and Herbicides

Somewhat similar statements apply to the possible adverse effects of insecticides and herbicides on water quality. Whatever problems may exist now or in the future are not necessarily associated with irrigation. It seems likely that insecticide problems are more likely to be encountered in humid areas. The greatest water pollution danger would probably exist when a high-intensity, short-duration rainfall occurs just after heavy application of an insecticide. One experience recently reported (*26*) indicates that a combination of rainfall and repeated applications of various insecticides, including a chlorinated camphene, resulted in the washing of sufficient toxic material into streams to cause major fish kills. There was concern over the safety of public water supplies involved, but apparently the low solubility of the insecticides used, together with water treatment, was sufficient to insure safety. Data on the fate of insecticides and herbicides in soil and water under a variety of conditions are needed.

Herbicides are employed for the control of weed growth in and along irrigation canals. Considerable research is in progress on herbicides and their use. According to Flaigg (*3*), no ill effects on water quality have been encountered in connection with the U.S. Bureau of Reclamation's operations involving the use of herbicides for canal weed control or destruction of salt cedars. Flaigg indicates that there is some evidence that 2,4-D is destroyed in moist soil by bacterial action and also that it may be immobilized in the soil by adsorption or by the formation of a relatively insoluble calcium salt. Possible difficulties associated with the use of 2,4-D and other weed killers have been cited by Goudey (*27*) and Surber (*28*).

References

1. Irrigation Agriculture in the West. *U.S. Dept. of Agriculture Misc. Pub.*, No. 670 (1948).
2. Houk, I. E. *Irrigation Engineering.* Vol. 1. John Wiley & Sons, New York (1951).
3. Flaigg, N. G. The Effect of Irrigation and Return Flow on Water Supplies. *Southwest Wtr. Wks. J.*, **34**:12:9 (Mar. 1953).
4. President's Materials Policy Commission. *Resources for Freedom.* U.S. Govt. Printing Office, Washington, D.C. (1952). Vol. 5, p. 83.
5. MacKichan, K. A. Estimated Use of Water in the United States—1950. *USGS Circ.*, No. 115 (1951).
6. *Hydrology Handbook.* Am. Soc. Civil Engrs., New York (1949), p. 136.
7. Consumptive Use of Water—A Symposium. *Trans. ASCE*, **117**:948 (1952).
8. Symposium on Water for Irrigation Use. *Chem. Eng. News*, **29**:990 (1951).
9. Thorne, J. P. & Thorne, D. W. Irrigation Waters of Utah: Their Quality and Use. *Utah Agric. Expt. Sta. Bul.*, No. 346 (1951).
10. Scofield, C. S. Salt Balance in Irrigated Areas. *J. Agric. Research*, **61**:17 (1940).
11. Clarke, F. W. The Data of Geochemistry. *USGS Bul.*, No. 770, p. 69 (1924).
12. Headden, W. P. Colorado Irrigation Waters and Their Changes. *Colo. Agric. Expt. Sta. Bul.*, No. 82 (1903).

13. Surface Water Supply of the United States, 1949. VI. Missouri River Basin. *USGS Wtr. Supply Papers,* No. 1146 (1951).
14. South Platte River Basin Water Pollution Investigation. U.S. Pub. Health Service, Cincinnati, Ohio (July 1950).
15. BANKS, H. O. & LAWRENCE, J. H. Water Quality Problems in California. *Trans. Am. Geophys. Union,* **34**:58 (1953).
16. WILCOX, L. V. The Quality of Water for Irrigation Use. *U.S. Dept. of Agric. Tech. Bul.,* No. 962 (1948).
17. LOWRY, R. L. Discussion—Consumptive Use of Water. *Trans. ASCE,* **117**: 1023 (1952).
18. LIPPINCOTT, J. B. Southwestern Border Water Problems. *Jour. AWWA,* **31**:1 (Jan. 1939).
19. Summary Report on Water Pollution: Southwest-Lower Mississippi Drainage Basins. *USPHS Pub.,* No. 160 (1951).
20. Initial Development Gunnison-Arkansas Project—Roaring Fork Diversion, Colorado. Appendix D, Water Supply. U.S. Bur. of Reclamation, Region 7, Denver, Colo. (Jan. 1950).
21. HILL, R. A. Salts in Irrigation Water. *Proc. ASCE,* **67**:975 (1941).
22. CRIDDLE, W. D. Consumptive Use of Water: Irrigated Crops. *Trans. ASCE,* **117**:991 (1952).
23. SAWYER, C. N. Some Aspects of Phosphates in Relation to Lake Fertilization. *Sew. Ind. Wastes,* **24**:768 (1952).
24. ———. Fertilization of Lakes by Agricultural and Urban Drainage. *Jour. NEWWA,* **61**:109 (1947).
25. RUDOLFS, WILLEM. Phosphates in Sewage and Sludge Treatment. I. Quantities of Phosphates. *Sew. Wks. J.,* **19**:43 (1947).
26. YOUNG, L. A. & NICHOLSON, H. P. Stream Pollution Resulting From the Use of Organic Insecticides. *Progressive Fish-Culturist,* **13**:193 (Oct. 1951).
27. GOUDEY, R. F. Chemical Weed Control. *Jour. AWWA,* **38**:186 (Feb. 1946).
28. SURBER, F. W. Control of Aquatic Growths in Impounding Reservoirs. *Jour. AWWA,* **42**:735 (Aug. 1950).

C. S. Howard

Regional Chemist, U.S. Geological Survey, Salt Lake City, Utah. (Publication of this discussion authorized by Director, U.S. Geological Survey.)

Water works supervisors, in increasing number, are casting a questioning glance in the direction of irrigation intake and outlet structures upstream from water plant intakes. Where the municipal supply is obtained from small, flashy streams, treatment plant personnel are well aware of the problems in treatment process control. Now they are wondering whether rapidly expanding irrigation use will add further water quality difficulties to those already present.

Irrigation waters may be considered as a source of stream pollution, along with industrial and municipal wastes. Pollution from irrigation is most noticeable in streams where the return waters have high mineral concentrations, but changes in the chemical character of waters with low or moderate mineral content may also cause appreciable pollution effects, particularly during periods of low stream flow. This pollution will frequently make the waters objectionable for industrial and domestic purposes as well as for additional irrigation. To show the presence and extent of pollution, it is necessary to have field and laboratory data for concentrations of dissolved minerals and the chemical character of the surface and ground water. The collection of data on the quality of natural surface waters of the United States was begun by the U.S. Geological Survey in 1906. These data have been published periodically in the USGS *Water Supply Papers* series (appearing annually since 1941). At present

chemical quality records are being obtained daily at more than 200 stations on the nation's streams, including 70 sampling stations that are related to irrigation activities or are considered potential sources of irrigation waters. Additional records are being collected less frequently at several hundred sampling stations. With these analytical data available, it is possible to compare records and to determine changes that have occurred. Plans can then be formulated for the best utilization of the country's water resources.

Dissolved Solids Concentration

Because much of the water used for irrigation is transpired by the plants or evaporated from the soil, return water from irrigated projects is ordinarily a smaller proportion of the amount diverted than is represented by the return water from flow diverted for industrial uses. This relatively high "consumptive use" for irrigation decreases the water supply and causes an increase in the dissolved-solids concentration of the residual water that enters the ground water reservoir or returns to the stream. The increases in dissolved-solids concentration result from four processes:

1. *Transpiration.* In the process of transpiration, plants take only small amounts of the soluble constituents from the water. Most of the soluble material of the irrigation water is left in the soil and eventually collects in the drainage waters.

2. *Solution and decomposition of soils and rocks.* In many areas where irrigation is required, the soils contain large quantities of salts that are dissolved during irrigation and returned to the stream in waste drainage waters.

3. *Evaporation.* An increase in dissolved-solids concentration occurs during the storage of water in reservoirs in dry, warm climates, owing to excessive evaporation from the water surface and, to a lesser extent, to transpiration by native vegetation growing around the reservoir.

4. *Reservoir storage effects.* A minor increase in dissolved-solids concentration during storage results from the solution of soluble salts of material on the reservoir site. This increase is sometimes partially or wholly offset by a decrease in the dissolved-solids concentration due to precipitation of certain constituents, chiefly silica and calcium carbonate, during storage.

Irrigation Use

Large volumes of water are required for irrigation. Although irrigation is practiced mostly in arid regions, there is an increasing amount in humid regions as well. Little is known about the effect of drainage waters from irrigated lands in humid areas, but it seems certain that the use of water for irrigation will create quality problems in any region. In arid sections, the crop requirements average approximately 2.5 ft of water per year for each acre of crop. If the land has large quantities of soluble salts, additional water is needed to leach them from the soil.

There is another use of water chargeable to irrigated projects: the loss through evaporation in reservoirs, in canals, or from the land surface. This evaporated water is lost from the basin and its volume is not available for downstream dilution; moreover, the dissolved-solids residue from the evaporated water is usually picked up by the drainage waters.

The use of water for irrigation in the upper part of a river basin is of considerable concern to consumers in the lower basin. Scofield (*1*) pointed out the pollution of streams that might take place through irrigation practices. Although he was referring primarily to the effect on future use for irrigation, his statements are pertinent to the present discussion. Goudey (*2*), in examining means of protecting ground waters, mentions their increased mineralization through irrigation use and the importation and exportation of waters from the basin. Exportation or transfer to another river basin often takes place in the headwaters area and removes the waters with the lowest concentration of dissolved substances. This removal results in a smaller volume of surface water for dilution of any wastes added to the stream. Dowd (*3*), discussing the water quality in the Lower Colorado River Basin asks: "Assuming full development in the Upper Basin, what will be the effect of the increased salinity in the river water at, say, Hoover Dam on its use for domestic and industrial purposes; that is, the effect on taste and on use of softened water for lawns, shrubs, flowers, etc., and on its use for manufacturing processes?"

The use of water for irrigation definitely decreases the volume available in the river basin. It also adds to the volume of soluble salts available to the streams of the basin, and use and reuse will result in a change in the chemical character of the surface waters.

Return Flow

For most irrigated lands to remain productive, it is necessary to have drainage, either natural or artificial. The drainage systems are sometimes planned when the irrigation canals are laid out, but, more often, the drainage is not installed for some years after the project has been started. Water is removed from an irrigated project by surface runoff and underground drainage. The surface runoff usually represents excess water and, on a well-planned project, will be slight. It often happens, however, that the surface runoff is appreciable, and it may be very turbid or muddy owing to erosion. The addition of this suspended matter to the stream may be a source of trouble for downstream users.

As pointed out previously, the drainage waters have a higher concentration of dissolved solids than the applied waters. Headden (*4*) discussed the quality of certain irrigation waters in Colorado and mentioned the changes that take place through irrigation. He described the Fort Collins water supply, obtained from the Poudre River. By comparison of analyses of the supply with analyses for upstream waters, he illustrated the effect of irrigation drainage on the public supply.

A study made by Washington State College showed the quality of the waters applied to and drained from the lands in the Yakima project (*5*). Analytical results indicated that the applied water was generally low in dissolved solids (less than 200 ppm), while the drainage waters had much higher concentrations (2,650 ppm, in one instance).

Salt Balance

Scofield (*6*) introduced the term "salt balance" as applied to irrigated areas and defined it as "the relationship of salt input to salt output." The Salinity Laboratory of the U.S. Dept. of

TABLE 9

Chemical Character of Waters Used for or Affected by Irrigation

No.*	SiO_2	Ca	Mg	Na	K	HCO_3	SO_4	Cl	NO_3	B	D.S.†	Cond.‡	Na
	ppm											*micro-mhos*	%
1.		34	5.5	18	§	113	47	6.7	0.5		199	289	27
2.		51	10	47	§	156	102	24	0.7		338	522	38
3.		68	16	95	§	181	198	69	1.4		596	889	47
4.		231	68	719	§	226	701	1,080	1.5		3,100	4,740	65
5.	9.3	9.6	1.9	3.8	2.7	42	5.2	1.1	0.8	0.0	56	79	19
6.	11	39	8.5	28	§	102	56	37	0.9	0.0	230	388	32
7.	12	46	10	37	§	156	55	34	2.6		273	460	34
8.	15	84	24	75	4.1	220	201	57	2.6	0.0	572	880	34
9.	13	86	25	93	§	162	267	75	2.7	0.0	642	986	39
10.	14	90	30	94	4.2	170	290	81	2.1	0.0	689	1,050	37
11.	13	31	14	197	§	98‖	328	99			730	1,170	76
12.		12	1.5	6.6	§	54	4.4	0.8	0.5		68	93	28
13.		56	26	204	§	282	291	109	1.8		876	1,300	64
14.		14	7.9	13	§	88	11	8.9	#		125	189	29
15.		52	40	102	§	257	25	196	0.2		610	1,043	43
16.	22	12	4.0	6.2	1.6	60	4.3	3.2	2.5	0.01	81	114	22
17.	43	54	22	60	8.6	250	114	22	1.4	0.05	463	692	36
18.	39	43	16	44	6.6	217	71	15	0.9	0.03	346	535	34
19.		3.0	1.1	4.6	0.2	18	4.1	1.6	0		39		44
20.		46	25	170	4.3	120	170	230	0.7		740		62
21.		28	9.4	96	2.4	110	76	110	0.5		410		65
22.		14	3.8	21	6.5	90	8.2	13	1.4		130		44

* Location and date:
1. Rio Grande at Otowi Bridge, near San Ildefonso, N.M.; weighted mean for 1948.
2. Rio Grande at San Marcial, N.M.; weighted mean for 1948.
3. Rio Grande at Leasburg Dam, near Rincon, N.M.; weighted mean for 1948.
4. Rio Grande at Fort Quitman, Tex.; weighted mean for 1948.
5. Colorado R. at Hot Sulphur Springs, Colo.; weighted average for 1948–49 water year.
6. Colorado R. near Glenwood Springs, Colo.; weighted average for 1948–49 water year.
7. Colorado R. near Cameo, Colo.; May 11–20, 1949.
8. Colorado R. near Grand Canyon, Ariz.; weighted average for 1948–49 water year.
9. Colorado R. below Hoover Dam, near Boulder City, Nev.; June 1–10, 1949.
10. Yuma Main Canal at Yuma, Ariz.; diversion from Colorado R.; June 1–10, 1949.
11. Treated water, Metropolitan Water Dist. of Southern California; 1947–48.
12. Boise R. at Dowling Ranch, near Arrow Rock, Ida.; Sept. 1–10, 1939.
13. Boise R. at Notus, Ida.; Sept. 1–10, 1939.
14. Weighted mean for "input" of District 1,500, Sutter Basin, Calif.; 1946–47.
15. Weighted mean for "output" of District 1,500, Sutter Basin, Calif.; 1946–47.
16. Weighted mean for Station No. 23, representing "input" for Sunnyside Valley Irrigation Dist., Yakima Project, Wash.; Mar. 1–Oct. 31, 1943.
17. Weighted mean for Station No. 2, one of the "ouput" sources of Sunnyside Valley Irrigation Dist., Yakima Project, Wash.; Mar. 1–Oct. 31, 1943.
18. Weighted mean for Station No. 15, one of the "output" sources of Sunnyside Valley Irrigation Dist., Yakima Project, Wash.; Mar. 1–Oct. 20, 1943.
19. San Joaquin R. at Friant Dam, Calif.; May 21, 1948.
20. San Joaquin R. above Merced R.; July 28, 1948.
21. San Joaquin R. at Hills Ferry Bridge; July 28, 1948.
22. Merced R. at Stevenson Drain, near Stevenson, Calif.; Sept. 27, 1948.

† Total dissolved solids.
‡ Specific conductance, 25°C.
§ Included with Na.
‖ Includes equivalent of 16 ppm carbonate.
Trace.

Agriculture, and its predecessor, the Rubidoux Laboratory, made studies of salinity and salt balance conditions in many irrigated areas of the West. Studies made in 1943 in the Sunnyside Irrigation Dist. of the Yakima River Basin in Washington indicated that there was a favorable salt balance (output equal to or greater than input) in the district. The analytical results showed that large quantities of soluble salts are discharged by drainage waters into the Yakima River (*7*). Analyses of the applied and drainage waters for this district are given in Table 9, No. 16–18.

Salt balance studies have been made in the Sutter Basin in California by the Dept. of Agriculture. This basin is a long depression between the Sacramento and Feather rivers and obtains its water from the former. The irrigation district is served by a system of open drains that empty into a single drain, and the drainage water is discharged back into the Sacramento River. The salt balance for this area was favorable for the years 1931, 1932, 1933, 1946, and 1947 (*8*). The quantity of salts in the output water ranged from 248 to 655 per cent of the quantity in the input water. The drainage waters had from five to eight times as high a concentration of dissolved solids as the applied waters. Typical analyses of the applied and drainage waters for this area are given in Table 9, No. 14 and 15.

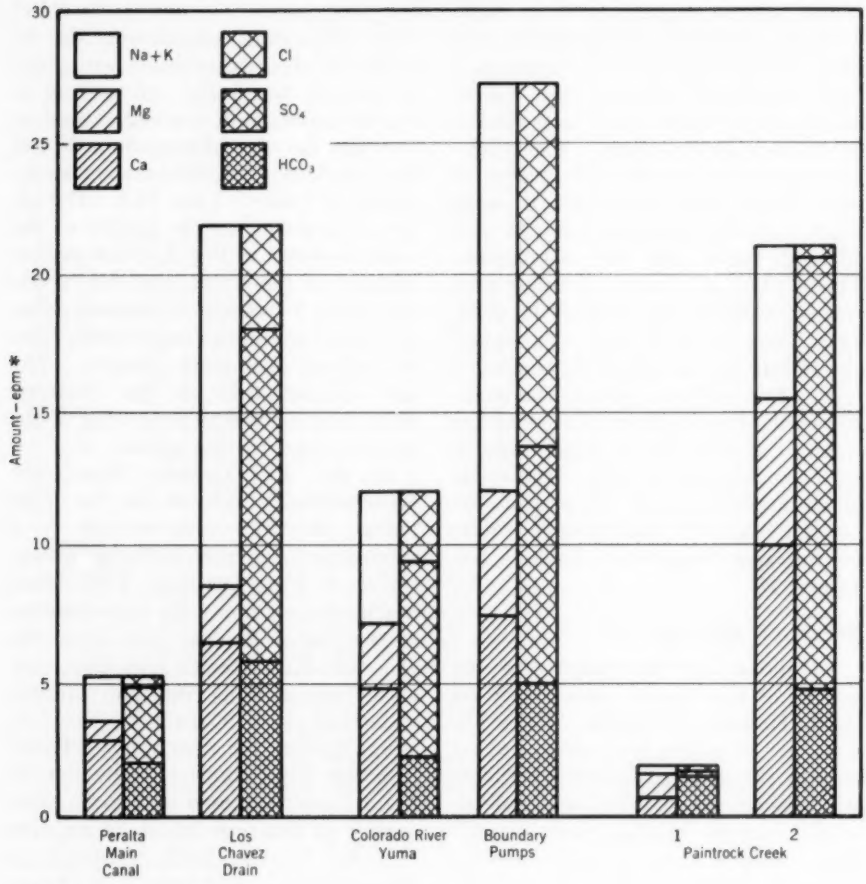
Effect on Quality

In discussing the quality of the waters of the Upper Colorado River Basin, Howard (*9*) stated: "Use of the water for irrigation and subsequent return to the stream of drainage waters will cause an increase in the dissolved-solids content of the river water." Most streams show a progressive increase in dissolved solids in a downstream direction, and it is not possible to say just how much of the overall increase is caused by irrigation drainage. Salinity conditions in the Rio Grande and Pecos basins are discussed in reports of the National Resources Planning Board (*10, 11*).

In the Colorado River Basin, the main river receives large quantities of soluble material from tributaries and irrigation drainage. In other papers, the author has discussed the increase in dissolved solids in the Grand Junction, Colo., area (*12*) and in the entire basin (*9*). Analyses showing the increase for the entire basin are given in Table 9, No. 5–10. An analysis of treated Colorado River water used as a supply for the Metropolitan Water Dist. of Southern California is also included in Table 9 (No. 11). The effect of drainage on the quality of the water is shown in Fig. 2, which depicts analyses of the water used for irrigation in the Yuma area (Colorado River at Yuma) and of drainage waters from the project (boundary pumps). The salt concentration of the drainage water was more than twice that of the applied water for the period.

In the Rio Grande Basin, the dissolved-solids content of the main stream increases progressively in a downstream direction, with the concentration at Fort Quitman, Tex., being nearly sixteen times the concentration at the Otowi Bridge, just below the Colorado–New Mexico state line. Analyses representing the Rio Grande water are given in Table 9, No. 1–4. An analysis of the river water diverted from the Rio Grande into the Peralta Main Canal is shown in Fig. 2. The quality of drainage water in an area irrigated by this kind of supply is shown in the same figure (Los Chavez Drain). The increase in concentration of dissolved solids is approximately fourfold.

In the Boise River Basin, water is diverted for irrigation in the vicinity of Boise, Idaho. Samples collected at Dowling Ranch represent the water released from Arrow Rock Reservoir, above all major diversions. Samples collected at Notus represent the river water below all diversions and most of the major drainage ditches of the Boise project. In September 1939 the in-



* Equivalents per million.

Fig. 2. Analyses of Waters Associated With Irrigation

The effect of irrigation on dissolved-solids content is illustrated in these "before" and "after" comparisons of Rio Grande (Peralta Main Canal and Los Chavez Drain), Colorado River (at Yuma and at irrigation project boundary pumps), and Paintrock Creek waters.

crease in dissolved solids in the river water between Dowling Ranch and Notus was 808 ppm. This increase was due largely to the discharge of drainage waters into the river (*13*). Analyses of samples collected at these two stations are given in Table 9, No. 12 and 13.

In the Paintrock irrigation project in western Wyoming, there was a considerable range in the chemical character of the natural waters (*14*). An-

alyses of two samples from Paintrock Creek are shown in Fig. 2. The increase in dissolved-solids content between the upper station, above irrigation (No. 1), and the lower station, below irrigation (No. 2), is about thirteen-fold and the hardness increase is approximately ninefold. The increase in dissolved solids and hardness is due to return irrigation water from lands between the two stations. It is anticipated that storage of water behind a proposed dam and additional use for irrigation will cause further changes in the water quality of Paintrock Creek.

In the San Joaquin River Basin in California, irrigation water comes directly from that river and through a system of canals from the Sacramento River. The quality of the San Joaquin water changes materially from the headwaters, just below Friant Dam, to the lower end of the basin, with the concentration of dissolved solids increasing in a downstream direction. Water from some of the tributaries—for example, the Merced River—has a dilution effect on the water in the main river (see Table 9, No. 19–22). The large quantities of soluble salts in the land are a source of the dissolved solids in the river and its tributaries. Under the present system of development, there is considerable reuse of the river water, so that irrigation practices in this basin have definite effects on the quality of the water available throughout the basin a short distance below Friant Dam.

Status of Control

The possibility of pollution through irrigation has not been widely recognized, perhaps because of the difficulty in determining the actual changes caused by irrigation practices. In a recent discussion of water quality problems in California, Banks and Lawrence (*15*) describe the inflow of irrigation drainage waters as one cause of the degradation of surface water quality. Some compacts and contracts for water delivery reflect concern over the effects of drainage on the quality of the water in the stream below irrigated projects.

The Rio Grande Compact (*16*) provides that "in the event any works are constructed after 1937 for the purpose of delivering water into the Rio Grande from the Closed Basin, Colorado shall not be credited with the amount of such water delivered, unless the proportion of sodium ions shall be less than 45 per cent of the total positive ions in that water when the total dissolved solids in such water exceeds 350 ppm." This statement applies to one area in the Rio Grande Basin. Elsewhere in the compact, this statement is made: "Nothing herein shall be construed as an admission by a signatory state that the use of water for irrigation causes an increase in salinity for which the user is responsible in law."

In the development of the Central Valley project in California, provisions have been made concerning the quality of the supply that will be available as a result of pumping water from the lower part of the basin for reuse in the project. A contract between the U.S. Bureau of Reclamation and the Contra Costa County Dist. provides that the district shall not be obligated to accept and pay for any water which contains more than 250 ppm chloride. An agreement between the Bureau of Reclamation and the Miller Lux interests in the San Joaquin Valley states that the weighted annual average of dissolved solids in the exchange waters

that have been provided for is not to exceed by more than 35 per cent the weighted annual average of dissolved solids in the Sacramento River at a certain location. Moreover, none of the substituted water is to be taken from a certain section of the San Joaquin River.

Few laws, compacts, or agreements have recognized that irrigation may be a cause of stream pollution, but it appears that more attention should be given to this matter.

References

1. Scofield, C. S. Stream Pollution by Irrigation Residues. *Ind. Eng. Chem.*, **24**:1223 (1932).
2. Goudey, R. F. Developing Standards for the Protection of Ground Water. *Jour. AWWA*, **39**:1010 (Oct. 1947).
3. Dowd, M. J. Problems of Imperial Irrigation District Relating to Salton Sea, Drainage, and Quality of Water. Paper read at 9th annual meeting of Colorado River Water Users Assn., Las Vegas, Nev. (Dec. 8–9, 1952).
4. Headden, W. P. Colorado Irrigation Waters and Their Changes. *Colo. Agric. Expt. Sta. Bul.*, No. 82 (1903).
5. Wright, C. C. Surface and Subsurface Waters of the Yakima and Klamath Reclamation Projects. *Wash. Agric. Expt. Sta. Bul.*, No. 228 (1928).
6. Scofield, C. S. Salt Balance in Irrigated Areas. *J. Agric. Research*, **61**: 17 (1940).
7. Wilcox, L. V. & Nelson, C. E. The Ground Water and Salt Balance Conditions of the Sunnyside Valley Irrigation District for the Period Mar. 1 to Oct. 31, 1944. Rubidoux Lab. Rept., U.S. Dept. of Agriculture (Mar. 1945).
8. Wilcox, L. V. Salt Balance Conditions of Reclamation District No. 1500 in Sutter Basin, California, for the Year Ending Dec. 31, 1947. Rubidoux Lab. Rept., U.S. Dept. of Agriculture (Apr. 1948).
9. Howard, C. S. Quality of Water in the Upper Colorado River Basin. *Trans. Am. Geophys. Union*, **29**:375 (1948).
10. National Resources Planning Board. *Regional Planning.* IV. Upper Rio Grande. U.S. Govt. Printing Office, Washington, D.C. (1938).
11. ———. *Regional Planning.* X. Pecos River Basin. U.S. Govt. Printing Office, Washington, D.C. (1942).
12. Howard, C. S. Transportation of Mineral Matter by Surface Water. In Meinzer, O. E. (ed.), *Hydrology.* McGraw-Hill Book Co., New York (1942; reprinted by Dover Publications, New York, 1949). p. 638.
13. Love, S. K. & Benedict, P. C. Discharge and Sediment Loads in the Boise River Drainage Basin, Idaho, 1939–40. *USGS Wtr. Supply Papers*, No. 1048 (1948).
14. Swenson, F. A. & Back, W. K. Ground Water Resources of the Paintrock Irrigation Project, Wyoming. *USGS Circ.*, No. 96, p. 31 (1951).
15. Banks, H. O. & Lawrence, J. H. Water Quality Problems in California. *Trans. Am. Geophys. Union*, **34**:58 (1953).
16. Rio Grande Compact Commission. Fifth Annual Report, 1943 (1944).

Relation of Irrigation Runoff to Tastes and Odors

By J. K. G. Silvey

A paper presented on May 14, 1953, at the Annual Conference, Grand Rapids, Mich., by J. K. G. Silvey, Chairman, Science Div., North Texas State Coll., Denton, Tex.

SEVERAL areas of the Southwest are dependent upon irrigation water for the production of crops. Rio Grande water is used for irrigation in Colorado, New Mexico, and Texas, in accordance with allocations provided for in the Rio Grande Compact. By the time the water reaches the southern tip of Texas, its mineral content has been increased by irrigation return flow, and various types of nutrient substances that would not otherwise be present are available.

The towns of McAllen, Mission, Harlingen, Weslaco, and San Benito, together with a number of villages also located in southern Texas, obtain their water supplies from canal systems off the Rio Grande. In this area, citrus fruits, vegetables, and other crops are produced with the aid of irrigation. For some time these cities have had to cope with serious problems of tastes and odors. Certain offending organisms have been isolated and studied to learn their nutritional requirements and the taste and odor compounds they produce (*1–3*). This information should be considered in relation to proposed irrigation projects.

Increases in the total mineral content of irrigation runoff water are dependent upon the type of water, the total mineral content prior to use, the type of crops raised, and the soil and climate of the region (*4*). Most water works personnel are aware of the many problems involved in the use of water from irrigation projects and the difficulty that municipalities experience in altering the water in their filtration plants to meet proper standards. Details of the effects of the constituents of such waters and their contributions to tastes and odors have not, however, received much consideration.

Nitrogen and Phosphorus

Minerals are essential to the growth of plants that support taste- and odor-producing organisms in water (*5*). Other conditions being equal, the greater the concentration of nutrient minerals (up to a point), the more extensive the growth of these supporting plants. Phosphorus and nitrogen are two of the elements that appear to act as limiting factors on the growth of aquatic organisms (*6, 7*). It has been said (*8*) that approximately 0.3 ppm of total nitrogen is necessary for the growth of certain aquatic organisms. For phosphates, the figure of 0.015 ppm has been given. Most commercial fertilizers contain nitrogen, phosphorus, potassium, and sometimes a number of rare elements not commonly found in soil. The nitrogen may be in the form of ammonia, nitrates,

or organic compounds. Most of the nitrogenous material is soluble in water and will contribute to the growth of plants, while the excess will remain temporarily in the soil. Runoff water returning to the rivers or present in the canals will carry soluble nitrogen. During certain times of the year the available nitrogen will increase in the waters of the rivers, reservoirs, or canals, resulting in the production of microscopic plants and animals and varieties of higher vegetation (*9*).

There has been considerable speculation on what happens to phosphorus when it is added to soil. It is known that clays act, in many respects, as ion-exchange compounds. Certain of the phosphates in calcium-bearing soils would be converted to calcium phosphates and remain in either the humus or the subsoil until the pH closely approached 7.0, at which time soluble phosphate would be eluted. The addition of superphosphates to soil would provide various types of phosphoric acid that might be available in the return flows or be tied up as organic phosphate in the plant materials.

Actual investigations on the phosphorus cycle in irrigated soils are meager and mostly incomplete. Some studies on the characteristic activity of phosphates when added to normal soils of the Southwest have recently been carried out at the Texas Research Foundation in Renner, Tex., employing "tagged" phosphorus. It was noted that, if 25 mg of tagged phosphorus is added to 1 liter of soil and water and the soil is dried out, later percolation of water through the soil will remove only 5 mg. These results apply specifically to the clays of the region under discussion. It was further shown that common cereal crops growing in land that receives phosphorus utilize approximately 60 per cent of the available phosphorus added. A high percentage of the amount utilized ultimately terminates in the leaf structure of the plant. In agricultural practice, the plant leaves are often permitted to return to the soil as organic matter. Organic phosphate is not soluble in water so long as it is part of the leaf (*6*). If, however, the accumulated vegetable remains containing organic phosphate are permitted to dry and disintegrate, the organic phosphate is oxidized first to insoluble and later to soluble phosphates. Should water then be added to the soil, some of the vegetable remains and the soluble phosphates will return to the river. Thus, if a plot of land remains submerged continuously, it appears that the available phosphates will be partially retained as organic phosphates and new minerals will have to be added before soluble phosphates increase. On the other hand, if the land is permitted to dry and, particularly, if it is plowed or cultivated in any fashion permitting the lower strata of the soil to be exposed to the atmosphere, oxidation will occur, converting the organic phosphates into a soluble form that dissolves in water and returns to the source stream. From these observations and from studies of water samples from the Rio Grande Valley of Texas, it is evident that phosphorus and nitrogen in the runoff flows from irrigated land increase the amount of available fertilizing materials found in streams (Table 1). It should also be noted that the humus layer accumulating on irrigated land does not often become a permanent stratum. This layer is broken down by bacteria,

molds, chemical compounds, thermal changes, and general oxidation. When the humus becomes extremely dry, it may hydrate readily or it may be inclined to float. Sudden additions of water to land that is already partially saturated—through rainfall, for example—may cause large concentrations of semicolloidal organic matter to be carried by runoff into a river that is ultimately used for domestic water supplies. Humus also contains varieties of organic compounds that may, in themselves, produce offensive tastes and odors in water or that may stimulate the growth of various types of simple organisms. Certain amines, esters, fatty acids, and even aromatic compounds are produced by higher plants in their normal physiology. It is likely that rare elements may be slowly leached from soils and serve as nutrients, aiding in the assimilation of nitrogen and phosphorus, so that the growth of microorganisms is expedited.

TABLE 1

Nitrate and Phosphate Content of Southwest Waters, 1952–53

River	Total N	NO_3	Total P	PO_4
	ppm			
Rio Grande (Valley)	3.40	0.58	0.82	0.21
North Canadian (Oklahoma City, Okla.)	1.14	0.16	0.08	0.003
Trinity (Elm Fork, Denton County, Tex.)	0.86	0.12	0.006	0.004
Trinity (West Fork)	0.64	0.04	0.005	0.002

Algae and Actinomycetes

Tastes and odors in raw water are contributed by myriads of organisms. A number of groups of plants normal to water may give rise to some tastes and odors. Both green and blue-green algae may grow in water, either floating or attached to the sides and bottoms of reservoirs. In addition to the algae, a number of higher plants, such as sedges, reeds, cattails, and grasses, grow in the shallow regions of reservoirs and contribute a large amount of organic matter to the water. The greater the percentage of phosphorus, the more extensive the growth of both algae and higher plants. As algae and higher plants become more numerous, microscopic animals and even certain types of fish increase in proportion to the available nutrients on which they depend (*6*). The entire biota of the lake, reservoir, or river will increase. In southwestern waters, these forms may become prolific enough to reduce the dissolved oxygen at night, resulting in a decomposition area devoid of oxygen and exuding offensive odors (*10*). Bacterial decomposition is a further source of odors. Although such a situation is not common, it does occur in shallow water where the daily temperatures exceed 100°F and ample nutrients are present.

The most common direct contributors of taste and odor are not algae, higher plants, or animals but organisms known as actinomycetes, which grow on or in the living algae and

plants and on the remains of dead animals (*4, 11*). The actinomycetes do not necessarily bring about the immediate decrease or death of the algae or the higher plants. The latter are capable of producing enough nutrients to sustain themselves as well as the actinomycetes (*11*). Byproducts of actinomycete metabolism, particularly the amino groups, appear to be reassimilated by particular plants, so that soluble phosphates continue in water supplies at a high level, the tastes and odors in the water would be contributed largely by higher plants, algae decomposition byproducts, and the constant destruction of animal and plant remains by various types of organisms. Such a condition, however, does not exist in rivers or reservoirs that are fed by irrigation return waters. As the nitrogen and phosphorus content

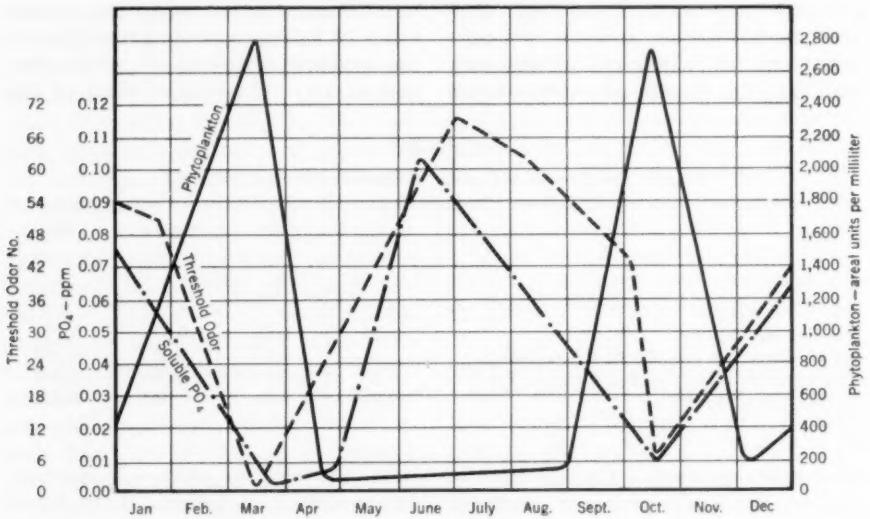


Fig. 1. Relation of Phosphates, Odor, and Plankton

The plankton population rises with the increase in soluble phosphates. The odor number increases owing to the destruction of algal cells by actinomycetes.

the nitrogen cycle within the plant is not dependent entirely upon the environment. If the actinomycetes produced all of the substances that the associated plants required, the situation would be beneficial for algae, higher plants, and actinomycetes alike. The lack of perfection in this association seems to be due to irregular supplies of available phosphates. Should will fluctuate in the return waters, the concentration of algae, higher plants, and microscopic animals will also vary. The flora attains a high population level owing to adequate supplies of phosphorus and nitrogen and, in doing so, removes large quantities of these chemicals from the water. If the phosphorus and nitrogen are not soon replenished, the population level of the

algae, higher plants, and animals cannot be sustained and begins to decrease.

The actinomycetes that live on and in the simple and complex plants are dependent upon such nutrients in the plants as organic nitrogen and carbon, while the plants are largely dependent on phosphorus and inorganic nitrogen. Lapse cinematography in the author's laboratory has demonstrated the existence of spores of actinomycetes in the interior of *Cladophora, Chlorella, Chlamydomonas, Nostoc, Anabaena, Gleocapsa, Melosira, Navicula, Pediastrum,* and *Aphanizomenon.* The length of time for which these genera of algae may exist with various types of spores in their interior has not been definitely determined. Observations by phase microscopy indicate that algal cells in a good state of repair have few spores. Those in the process of deterioration have a high population density. It appears that the actinomycete concentration is higher in deteriorating algae cells than in cells that appear to be healthy.

From these observations and from limnological findings in Lake Dallas, Eagle Mountain, Lake Worth, Bridgeport, Ranger, and Waco, Tex., and Oklahoma City, Okla., water supplies (*4, 11*), it is hypothesized that the actinomycetes living in the interior of algal cells exist in an imperfect symbiotic condition with the algae. As long as the algae obtain ample quantities of nutrients, this association persists. When the plants lose their ability to increase or sustain themselves, the actinomycetes alter their association from a symbiotic relationship to a saprophytic or parasitic one. This results in a rather rapid destruction of the plants, with a concurrent liberation of the byproducts of the metabolic activity of the actinomycetes. These metabolic byproducts are essentially the substances that give rise to tastes and odors in water. The substances produced by the actinomycetes under symbiotic conditions are different from those produced in the plants that are in the process of deterioration. Later data will support these conclusions.

There are sporadic occurrences of taste and odor compounds in water supplies that may or may not contain a high population of planktonic algae, attached algae, or higher plants. In the Southwest, rivers and reservoirs may contain taste and odor compounds, but few, if any, types of algal organisms may be collected (*4, 11*). On the other hand, lakes, reservoirs, and rivers have demonstrated prolific concentrations of algae with no apparent occurrence of tastes and odors (*12*). An explanation of these conditions may be found by examining the curves in Fig. 1, which represent the planktonic algae (mostly *Melosira*), the available soluble phosphates, and the threshold odor numbers of Lake Dallas water. It will be observed that the plankton pulses occurred prior to the production of odors. The highest threshold odors were present after the organisms had been deposited on the bottom of the reservoir. When more soluble phosphates became available, an additional bloom occurred, actinomycete destruction of the algal cells increased, and threshold odors again began to rise. Thus, when the relationship between actinomycetes and algae became saprophytic or parasitic, byproducts liberated from the algal cells as they disintegrated diffused into the water and gave rise to intense tastes and odors.

Actinomycete Byproducts

The type and quantity of substances produced by actinomycetes associated with algae, higher plants, or animal remains will vary. Different strains of actinomycetes form different by-

mer of 1951 (type collection number NT-OO-S1-8-A-16). These actinomycetes were reared with *Chlorella* and *Cladophora,* as well as on nutrient media.

Pure cultures of these algae were reared on nutrient media, allowed to

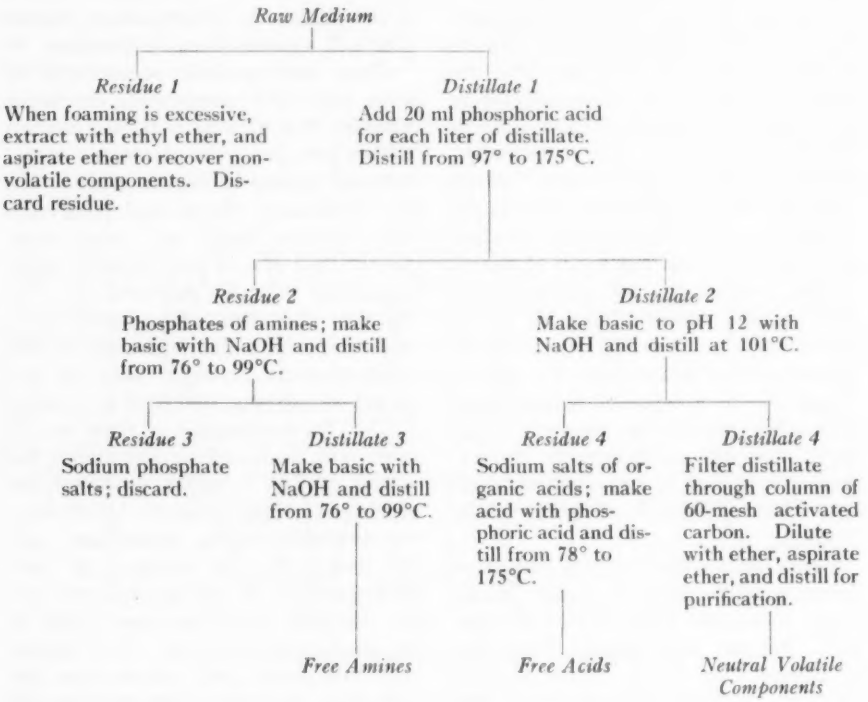

Raw Medium
Residue 1
When foaming is excessive, extract with ethyl ether, and aspirate ether to recover non-volatile components. Discard residue.
Distillate 1
Add 20 ml phosphoric acid for each liter of distillate. Distill from 97° to 175°C.
Residue 2
Phosphates of amines; make basic with NaOH and distill from 76° to 99°C.
Distillate 2
Make basic to pH 12 with NaOH and distill at 101°C.
Residue 3
Sodium phosphate salts; discard.
Distillate 3
Make basic with NaOH and distill from 76° to 99°C.
Residue 4
Sodium salts of organic acids; make acid with phosphoric acid and distill from 78° to 175°C.
Distillate 4
Filter distillate through column of 60-mesh activated carbon. Dilute with ether, aspirate ether, and distill for purification.
Free Amines
Free Acids
Neutral Volatile Components

Fig. 2. Distillation Scheme

Taste and odor compounds were obtained from algae-actinomycete culture media in accordance with the scheme illustrated.

products, depending somewhat upon the nutrients furnished. The data contained in this paper are based on experimental work with an actinomycete species of the genus *Streptomyces,* isolated from *Cladophora* in Lake Overholser at Oklahoma City in the sum-

attain a concentration of 1,000 areal units per milliliter, and then transferred to distilled water to serve as sources for experimental nutritional investigations. The life history of spores of actinomycetes introduced into pure algae suspensions was fol-

lowed by lapse cinematography, so that the time of spore penetration and the development of odor compounds could be determined. Similar experiments conducted on pure cultures of algae alone did not develop taste and odor compounds like those described in this paper.

Twenty-four hours after the spores had been introduced into the algal suspensions, motile microarthrospores appeared in the algal cells. When a part of the fluid medium or distilled water was extracted with ethyl ether and the other part was exposed to the distillation scheme shown in Fig. 2, actinomycete byproducts were recovered. The first byproducts formed were free amines (methyl, dimethyl, and butyl) and simple amino acids (glycine and alanine). When these compounds were placed in water in concentrations of 40–60 parts per billion, a fishy odor resulted. When the algae and actinomycete association was permitted to continue to 48 hr, there appeared to be a slight disintegration of the algal cells. Separating the medium from the organisms and exposing it to distillation and extraction following the scheme illustrated in Fig. 2 led to the recovery of valeraldehyde and other, undetermined, short-chained aldehydes. Placing these compounds in water in concentrations of 20–40 parts per billion resulted in musty, grassy, and haylike odors.

If the actinomycete-algae association is allowed to continue until there is obvious destruction of the interior of the algae, with occasional disintegration of cellular walls, additional compounds may be recovered from the medium. These are saturated fatty acids such as butyric, isobutyric, and valeric, which, in concentrations of 10–40 parts per billion, produce earthy, musty, and pungent odors. If the algae go into a state of complete disintegration, still other compounds may be extracted and distilled from the medium. Some of these are aromatic substances whose identity is unknown. When these products are added to water in concentrations of 5–20 parts per billion, their odor is detectable. The odor characteristic appears to be somewhat inconstant. In the last stages of deterioration, esters, ketones, and lactones have been removed from the medium as byproducts of actinomycete metabolism.

Conclusion

The author is aware that pure cultures of algae do not occur in nature and that all algae do not contain spores of actinomycetes. The ecological factors that contribute to the invasion of algal cells by actinomycete spores have not been determined. Nevertheless, because a large proportion of the algal forms from lake and reservoir collections show motile spores on their interior, the author has proposed the hypothesis previously described. Laboratory and field data support the concept that phosphates are a limiting factor. Consequently, the author is seriously inclined to offer the association of actinomycetes and algae in different stages as the major cause of tastes and odors in water supplies. Moreover, the same laboratory and field data support the assertion that algae alone do not contribute taste and odor compounds in their normal physiology.

It may, therefore, be concluded that irrigation return flows containing phosphates and inorganic nitrogen will in-

crease the frequency of sieges of tastes and odors in surface waters.

References

1. Silvey, J. K. G. Actinomycetes in Water Supplies. Progress Rpt. of Research Grant No. 329 (2C). National Institutes of Health, Bethesda, Md. (1951).
2. ———. Factors Affecting Actinomycete Growth in Water Supplies. Progress Rpt. of Research Grant No. 329 (3C). National Institutes of Health, Bethesda, Md. (1952).
3. ———. Actinomycetes and Common Tastes and Odors. *Jour. AWWA*, **42**:1018 (Nov. 1950).
4. Howard, C. S. Irrigation, a Source of Stream Pollution. USGS Congress of Pure and Applied Chemistry (1951).
5. Welch, P. S. *Limnology*. McGraw-Hill Book Co., New York (1952). p. 538.
6. Neess, J. C. Development and Status of Pond Fertilization in Central Europe. *Trans. Am. Fisheries Soc.*, **76**: 335 (1949).
7. Hutchinson, G. E. Limnological Studies in Connecticut. VII. A Critical Examination of the Supposed Relationship Between Phytoplankton Periodicity and Chemical Changes in Lake Water. *Ecology*, **25**:1:3 (1944).
8. Chu, S. P. The Influence of the Mineral Composition of the Medium on the Growth of Planktonic Algae. II. The Influence of the Concentration of Inorganic Nitrogen and Phosphate Phosphorus. *J. Ecology*, **31**:2:109 (1943).
9. Mortimer, C. H. The Nitrogen Balance in Large Bodies of Water. *Wtr. & Wtr. Eng.* (1939).
10. Wiebe, A. H. Nocturnal Depression in the Dissolved Oxygen in Fish Ponds With Special Reference to an Excess of Coarse Vegetation and of Fertilizers (Texas). *Trans. Am. Fisheries Soc.*, **64**:181 (1934).
11. Silvey, J. K. G. & Roach, A. W. Actinomycetes in the Oklahoma City Water Supply. *Jour. AWWA*, **45**:409 (Apr. 1953).
12. Redden, D. R. The Physical, Chemical, and Biological Factors Contributing to Algae Blooms in Fresh-Water Reservoirs. Thesis, North Texas State College, Denton, Tex. (1949).

Synthetic-Detergent Pollution in Kansas

By Russell L. Culp and Howard A. Stoltenberg

A paper presented on May 14, 1953, at the Annual Conference, Grand Rapids, Mich., by Russell L. Culp, Chief, Water Supply Section, and Howard A. Stoltenberg, Chief Chemist, Water and Sewage Lab.; both of the Kansas Board of Health, Lawrence, Kan.

DURING January and February 1953 very unusual difficulties were experienced in the operation of the Osawatomie, Kan., municipal water softening plant.

Osawatomie, a town of 4,500 persons, is located on the Marais des Cygnes River, from which it obtains its water supply. The raw water is processed in a modern softening plant of conventional design. Treatment consists of rapid mixing, flocculation, settling, single-stage recarbonation, rapid sand filtration, and chlorination. The raw water is used for power plant cooling before treatment, which raises the raw-water temperature approximately 5°F. The treatment plant was constructed in 1939. Although the water demands are approaching those for which the plant was designed—1 mgd—all raw-water conditions encountered prior to 1953 were handled by the available facilities with a minimum of operating trouble.

The principal city in the Marais des Cygnes River watershed above Osawatomie is Ottawa, Kan., which has a population of 11,000 and is situated 28 river miles upstream. Ottawa also obtains its water supply from an impoundment on the Marais des Cygnes River. Water treatment at Ottawa is similar to that at Osawatomie, except that double flocculation and settling are provided. Ottawa discharges its sewage into the stream, following treatment in a modern, well-designed, and efficiently operated activated-sludge plant. Late in 1952 extensive additions and improvements were completed at the Ottawa sewage plant to provide a capacity adequate to serve the city for a number of years in the future.

Operating Difficulties

The operating difficulties at the Osawatomie water plant were preceded by 6 months of low flow in the river. During January, although the impounding reservoir was full at all times, the flow was low, varying from 1 to 7 cfs in the river below Ottawa. During the first 2 weeks of January the river was under almost complete ice cover. The thawing and disappearance of this ice cover, however, did little to relieve conditions at the water plant. Figure 1 shows the overflow dam after the ice cover had melted, with some froth on the water surface below the dam. At times the froth covered the water surface below the dam to a depth of several inches and extended several hundred feet downstream.

On Jan. 6, J. J. Higgins, superintendent of utilities at Osawatomie, called the Kansas Board of Health to

report trouble and to say that there was some question as to how long normal operation of the water plant could be maintained under the prevailing conditions. The raw water was clear (turbidity 10 ppm), highly colored (color 50), and had a very strong fishy taste and odor. The river water temperature was near freezing. Under normal softening procedures, using approximately 200 ppm of lime and 34 ppm of alum, a large floc would form quickly but the settled water was cloudy, apparently as a result of delayed reaction between lime and carbonate hardness. The coagulation and settling basins were covered with several inches of floating material, and, in addition, there was considerable froth on the water surface in the coagulation basin. Figure 2 is a view of the coagulation basin showing approximately a 4-hr accumulation of scum. This picture was not taken at the peak of the trouble, but after some improvements in operation had been made. There was more serious interference with settling than with flocculation. Superintendent Higgins estimated that, under the worst conditions, approximately 70 per cent of the coagulated material came to the top of the basins; 10 per cent settled to the bottom in the normal manner; and 20 per cent was carried to the filters. Rising gas bubbles were observed throughout the plant, particularly in the water above the filters. Successive filter runs were reduced from 100 to 40 hr, then to 12, and finally to 7 hr by Jan. 6. The filtered water was colored and slightly cloudy, and it had a strong, disagreeable, fishy taste and a faint odor. At Higgins' suggestion, softening was discontinued and the application of lime and carbon dioxide stopped.

Fig. 1. Osawatomie Dam

The river is shown during a low-flow period, after the ice cover had melted. Froth is visible on the water surface.

Fig. 2. Coagulation Basin

A 4-hr accumulation of scum can be seen. This photograph was taken after some improvements in operation had been made.

On their first visit to the plant, the authors found that the elimination of softening had slightly reduced the amount of floating and suspended ma-

terial. Filter runs had been increased to 12 hr, but other conditions remained the same.

Laboratory and Plant Tests

Numerous tests were made in the plant laboratory in an attempt to find methods for improving coagulation and sedimentation and for removing taste, odor, and color. Free residual chlorination and activated carbon treatment were the first processes tested in the laboratory. Figure 3 shows the results of the chlorination tests. A definite "breakpoint" was found at a dosage of approximately 10 ppm. No taste or odor was detected in the sample dosed with 10–15 ppm of chlorine. It should be noted that, beyond the breakpoint, increments of 1 ppm chlorine produced slightly less than 1-ppm increases in chlorine residual. Complete color removal was obtained. Activated carbon, at dosages of approximately 40 ppm, also successfully removed the color, taste, and odor, but, because it was not practical to apply such high dosages in this plant, no attempt was made to utilize the process on a plant scale. Microscopic examination of water samples failed to show the presence of significant numbers of taste-producing organisms. A number of coagulants were given jar tests to determine their efficiency in treating the water. Alum, alum–activated silica, alum-lime, alum-bentonite, and ferric chloride were used in various dosages. Because of the great number of jar tests performed and because only general observations were made, the individual tests are not tabulated in this paper and the results are merely summarized.

It was soon apparent that the tendency for floc particles to rise to the surface was dependent upon the surface area of the particles and not on their density or on the nature of the coagulant used. Particles with relatively large surface areas would adsorb a greater number of minute gas bubbles than the smaller, more compact particles. This phenomenon—the rising of previously settled material—has previously been reported by Cross (*1*). Best results without pH adjustment (at pH 7.9) were obtained with alum and activated silica. A small, dense floc that settled readily, with little or no floating material, resulted from the application of 25 ppm of alum and 1 ppm of activated silica, and color removal was fair. Good results were also obtained with 25 ppm of alum and 50 ppm of lime (at pH 8.3). The application of 25 ppm of alum plus 10–100 ppm of bentonite produced a large floc. With bentonite doses of 40 ppm or less, the liquid remained cloudy despite the good floc formation. At 100 ppm bentonite, the liquid was clear, but much floating floc was observed.

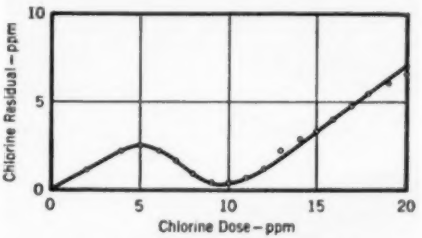


Fig. 3. Chlorine Test Results

The "breakpoint" occurs at approximately 10 ppm.

Following this first group of laboratory tests, arrangements were made in the plant to provide free residual chlorination and to apply activated silica. Sodium bicarbonate was used as the activating agent, and a constant-head feeder was improvised for the silica sol.

The plant was operated for several days with dosages of 10 ppm of chlorine, 25 ppm alum, and 1 ppm activated silica. Complete color removal was obtained. A good, small, dense floc was obtained, and the amount of floating material was substantially reduced. The floating material was not completely eliminated, as illustrated by Fig. 4, which shows the flocculation basin being skimmed. This became a daily operation, and an opening was cut in the basin to facilitate disposal of the scum. Filter runs were only slightly increased, to approximately 16 hr. The taste and odor condition of the finished water was greatly improved. The odor was eliminated, and the fishy taste was replaced by a less intense one, described by various persons as rancid, bitter, or soapy. The failure to eliminate all tastes completely was a disappointment, as jar tests had indicated that this could be accomplished. Apparently the actual chlorine contact time in the plant was insufficient and was less than the 3 hr used in the jar tests.

Fig. 4. Skimming Coagulation Basin

The application of chlorine, alum, and activated silica reduced, but did not eliminate, the floating material. The basin still had to be skimmed daily.

Ottawa Sewage Study

Knowing that the Ottawa water plant was utilizing the same river as a source of supply, the authors made a trip there to see whether a similar problem existed. Everything was found to be normal: the raw water was clear (turbidity 10 ppm) and colorless, with no objectionable taste or odor, and there was no trouble in treatment.

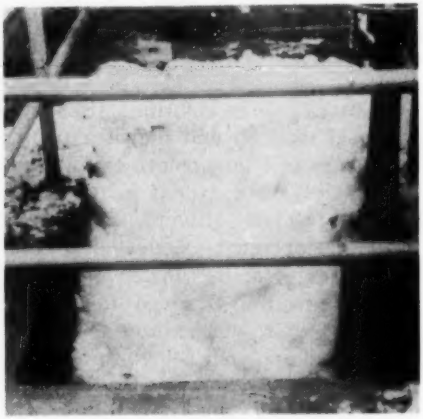


Fig. 5. Ottawa Sewage Plant Outfall

The frothing pictured is an average condition.

The authors then visited the Ottawa sewage plant, which gave the first hint that synthetic-detergent pollution introduced into the river at Ottawa might be a contributing factor in the trouble at the Osawatomie water plant. Figure 5 shows the effluent weir chamber at the Ottawa sewage treatment plant. The frothing pictured is an average condition. The operators report that, under extreme circumstances,

froth accumulates to a depth of several feet and extends for 100 ft or more downwind from the plant site. Froth also forms on the surface of the river below the sewage plant outfall. The opinion of sewage plant personnel that frothing troubles started at the time synthetic-detergents were first used residentially, and have become progressively worse despite increased plant capacity, together with the maintenance of relatively high mixed liquor solids (approximately 1,400 ppm) in the aeration tanks, led the authors to investigate the possibility of synthetic-detergent pollution of the Osawatomie water supply.

Numerous samples were analyzed for total anionic synthetic-detergent content by the improved methylene blue method (*2*). Essentially, this method consists of extraction of the methylene blue-detergent complex by means of chloroform, and photometric estimation of the color intensity of the chloroform layer. Average results are shown in Table 1. In this discussion the term "synthetic detergent" denotes the complete product as it is used, including auxiliary components and the active detergent itself.

The ratio of 39 ppm of detergent in the Ottawa treated sewage to 6.6 ppm of detergent in the stream just below the plant corresponds exactly to the dilution of treated effluent afforded by the river at the time samples were taken.

The value of 44 ppm of synthetic detergents in the Ottawa sewage agrees closely with the value of 45 ppm given for Aurora, Ill., by Sperry (*3*) and with the value of 42 ppm estimated for Indianapolis, Ind., by Bowers (*4*). An additional check was obtained through the cooperation of O. L. E. Haff, superintendent of utilities at Ottawa, who made a survey of all local retail synthetic-detergent sales. As the sewage plant effluent is metered, it was possible to divide the total number of pounds of detergent sold per month by the total sewage flow during the same period. This calculation gave a figure of 53 ppm of synthetic detergent. Considering that some of the retail sales were made to rural customers not served by the sewer system, the figure of 53 ppm, based on sales, checked very well with the average value of 44 ppm obtained by chemical analysis of the raw sewage.

TABLE 1

Total Anionic Synthetic-Detergent Content (Marais des Cygnes River)

Sampling Point	Synthetic Detergent Content *ppm*
River, above Ottawa	0.4
Raw sewage, Ottawa	44.0
Treated sewage, Ottawa	39.0
River, just below Ottawa	6.6
River, at Rantoul (12 miles downstream from Ottawa)	4.5
River, at Osawatomie	3.9
Tap water, Osawatomie	3.6

Osawatomie Results

In view of the fact that the Osawatomie tap water contained 3.6 ppm of synthetic detergents, laboratory tests were made in which distilled-water samples containing various brands and concentrations of synthetic detergents were chlorinated. Rancid tastes similar in character to those present in the Osawatomie tap water were reproduced by this method.

The use of chlorine dioxide, to alleviate a taste problem which was believed to be due to the presence of synthetic detergents had been reported (*1*) at Appleton, Wis. Through the

courtesy of Robert Mounsey, Water Supt., Lawrence, Kan., equipment was borrowed to prepare and apply chlorine dioxide in the Osawatomie water plant. Free residual chlorination was continued, by adding 10 ppm of chlorine in the rapid-mix basin, and 2 ppm of chlorine dioxide was applied to the filter influent. Beneficial results were immediately apparent in the filter effluent. In a few days consumer complaints ceased. The chlorine dioxide treatment was later reduced to 1 ppm, with equally good results. The local residents were very pleased and considered the water to be entirely satisfactory. The authors, being visitors, were able on a few occasions to detect a very slight trace of the rancid taste, which probably was not pronounced enough to be of practical importance.

On Feb. 20 there was 0.8 in. of rainfall over a part of the Marais des Cygnes watershed. By Feb. 25 the trouble at the Osawatomie water plant was temporarily relieved. Free residual chlorination was continued, but it was possible to stop the chlorine dioxide treatment, and softening was resumed. The synthetic-detergent content of the raw water was reduced to 2.7 ppm by the increased flow in the river, with very little rise in turbidity. The lowered synthetic-detergent content did not interfere with normal treatment processes.

This situation offered an excellent opportunity to find out whether the difficulties experienced previously with poor settling in the plant were due principally to the synthetic detergents or to other factors. Jar tests were performed on raw water containing 2.7 ppm synthetic detergents, and the plant scale results were duplicated; that is, satisfactory flocculation and settling were obtained with alum alone and also with alum and lime in quantities required for softening. Similar tests were made on samples of the same water to which 2 ppm of synthetic detergent had been added, bringing the total synthetic-detergent content to 4.7 ppm. The latter samples, when treated with alum alone, produced a high percentage of floating floc; samples treated with alum and softening doses of lime were cloudy after flocculation and had a large amount of floating material on the water surface. There was some variation in the results with different brands of synthetic detergents. Thus, the difficulties previously experienced in plant operation were reproduced by the addition of synthetic detergents to water that was being satisfactorily handled in the plant. The results of this experiment indicate rather definitely that synthetic detergents are the main source of trouble at the Osawatomie plant. Low water temperature, decomposing organic matter, and other factors may also have been involved to a limited extent.

By Mar. 7 decreased flow in the river had caused the synthetic-detergent content of the raw water to reach 3.5 ppm. A crust of floating floc was again forming on the surface of the basins, and the operators were preparing to resume the emergency treatment procedures when additional rainfall made changes unnecessary.

From the above data, it was established that the minimum synthetic-detergent content of the Marais des Cygnes River water which would interfere with treatment was 3.0–3.5 ppm. Serious interference occurred at synthetic-detergent concentrations of 3.9 ppm or more. These results of actual plant operation are in substantial agreement with laboratory data

obtained by Cross (*1*) in jar tests of coagulation performed by adding known amounts of various brands of synthetic detergents to Lake Michigan water.

On the basis of the Osawatomie experience, it appears that synthetic detergents in the concentrations now occurring in sewage will not cause difficulty to downstream water plants unless the dilution afforded by the receiving stream is less than 10:1.

General Considerations

Synthetic detergents are rapidly attaining dominance as cleansers in industry and in the household. Sales rose from zero in 1928 to 0.1 bil lb in 1941 and to 1.5 bil lb in 1952. Consumption is expected to exceed 2 bil lb annually in the near future.

The recently published *Encyclopedia of Surface-Active Agents* (*5*) lists more than 2,500 commercial brands. The active anionic detergents of chief interest to those concerned with water treatment are the alkyl aryl sulfonates and the fatty alkyl sulfates, as these form the base for 83 per cent of the products sold. The ordinary household package of synthetic detergent contains 30–35 per cent of pure organic detergent (*6*). The other principal ingredients include such compounds as sodium tripolyphosphate, tetrasodium pyrophosphate, carboxymethylcellulose, sodium sulfate, sodium chloride, alkaline builders, organic builders, perfumes, and fluorescent dyes. Many of these auxiliary components are fully as important to the water works operator as the synthetic detergent itself. The polyphosphates particularly may have a great influence on colloidal behavior.

Detergent action is fundamentally at variance with water treatment processes. "A good detergent lifts and disperses all the types of dirt and grease which occur in a product to be cleaned, whereas water purification is for the purpose of removing as much dispersed material as possible" (*7*). The synthetic detergents are excellent wetting, foaming, emulsifying, dispersing, and deflocculating agents. They sharply lower the surface and interfacial tension (*4*). They have the ability to solubilize or suspend substances not normally soluble in water (*7*). They are stable and retain their properties even in extreme dilution and under conditions of pH change, oxidation, and digestion by microorganisms (*7*).

The popularity of synthetic detergents with the housewife and in industry assures their continued and increased use. Persons responsible for the treatment of sewage and industrial wastes and the operation of public water supply systems might properly devote more attention to synthetic detergents and the auxiliary components of these washing products, in order to determine in greater detail all of the possible effects upon sewerage systems, streams receiving the waste products, and water treatment. Such studies will aid in meeting new problems as they arise. The synthetic-detergent industry has already shown that it can be depended upon to do its part in cooperative investigations to solve these difficulties.

Considerable work has been done in the past few years to determine the effects of synthetic detergents upon sewage treatment, particularly with regard to frothing (*8–10*). The results of these studies indicate that synthetic detergents do not contribute greatly to frothing in sewage works. Other studies show substantial removals of

detergent by normal sewage treatment processes. Much of this work, however, was of necessity done by adding a pure synthetic detergent solution in the plant, and it is possible that the actual conditions of use, in which a corresponding amount of synthetic detergent is dissolved in hot water, along with grease and dirt from the kitchen and laundry, may produce very different effects. Although froth formation has received most of the attention and publicity, it is only a single, relatively minor factor in the overall effect of detergents on sewage treatment. In water works operation, it may be of little or no importance.

At Bradford, England, a textile city, wool-scouring wastes are treated in the sewage plant. Formerly wool greases were removed by the sulfuric acid method of recovery as a byproduct and were sold to provide funds to operate the sewage treatment plant. With an increased concentration of synthetic detergents, the wool grease remains dispersed and cannot be efficiently separated or recovered (*7*). This example illustrates the effects synthetic detergents may have on grease from the home laundry and sink, and indicates the possible influence on tastes and odors in downstream water supplies.

The phosphorus content of domestic sewage is approximately twice what it was before the advent of synthetic detergents (*7*). Phosphorus is generally recognized as a key element in the stimulation of the growth of algae. Although objectionable forms of algae were not a factor at Osawatomie, because of the season of the year, there is a possibility that they will become important in the summer months, during low river stages.

Research (*11*) has demonstrated that anionic and nonionic synthetic detergents stimulate bacterial slime growths in sewage. The effect on the balance of aquatic life in the stream is unknown, but it may also influence the quality of water received by downstream users.

TABLE 2

Total Anionic Synthetic-Detergent Content, Neosho River, 1953

City	Date Sampled	Synthetic-Detergent Content—*ppm*			
		Raw Water	Tap Water	Treated Sewage or Sewage Outfall	Below Sewage Plant or Outfall
Emporia	Mar. 6	0.8	0.6	15.0	1.4*
Burlington	Mar. 2	0.8	0.5	33.0	1.0
Le Roy	Mar. 5	0.8	0.7	27.0	1.0
Iola	Mar. 3	0.7	0.5	20.0	11.0†
Humboldt	Mar. 2	1.0	1.0	34.0	1.2
Chanute	Feb. 28	1.0	0.9	29.0	1.9
Parsons	Mar. 4	0.9	0.8	22.0	
Oswego	Mar. 2	1.2	1.0	4.1	1.4
Chetopa	Mar. 7		2.2	4.6	1.2

* Cottonwood River.
† Creek before entering Neosho River.

Neosho River Study

After the troubles at Osawatomie, the Kansas Board of Health became concerned about the possible future problems that could very well arise in treating Neosho River water for drinking purposes. This stream, for its length, is one of the most heavily used water supply sources in the country. Twelve cities use it for both water supply and sewage disposal. A special survey was made in order to anticipate future conditions on the Neosho. The results are given in Table 2. Again the term "synthetic detergent" denotes the complete product as it is used, including auxiliary components and the active detergent itself.

Flows were considerably higher in the Neosho River, in proportion to the discharge of sewage, than in the Marais des Cygnes River, and the concentration of synthetic detergents was not sufficient to cause trouble at the time of the survey. The data indicate that some difficulty may occur during extremely low flows in the Neosho. If this happens, the department hopes to be in a better position to handle the situation, as a result of the Osawatomie experience and the availability, in the future, of new information on the problem of treating water containing synthetic detergents.

References

1. Cross, J. T., et al. Effects of Synthetic-Detergent Pollution. *Jour. AWWA*, **42**:17 (Jan. 1950).
2. Degans, P. N., Jr.; van der Zee, H.; & Kommer, J. D. Anionic Syndets in Amsterdam Sewage. *Sew. Ind. Wastes.*, **25**:20 (1953).
3. Sperry, W. A. Detergents and Their Influence on Sewage Treatment. *Sew. Ind. Wastes*, **23**:1469 (1951).
4. Bowers, D. R. Measurement of Surface Tension of Sewage. II. Indianapolis Studies. *Sew. Ind. Wastes*, **24**: 1447 (1952).
5. Sisley, J. P. & Wood, P. J. *Encyclopedia of Surface-Active Agents.* Chemical Publishing Co., New York (1952).
6. Flett, L. & Hoyt, L. F. Detergent Compounds—Their Composition and Behavior. *Sew. Ind. Wastes*, **25**:245. (1953).
7. Effect of Detergents on Sewage and Water Treatment. *Chem. Eng. News*, **31**:1072 (1953).
8. Gowdy, W. R. Chemical Structure and Action of Synthetic Detergents. *Sew. Ind. Wastes*, **25**:15 (1953).
9. Furman, R. E. & Rice, J. E. Operating Experiences at Washington, D.C. *Sew. Ind. Wastes*, **25**:277 (1953).
10. Gowdy, W. R. Action of Detergents in Sewage Treatment. *Sew. Ind. Wastes*, **25**:255 (1953).
11. Manganelli, R. & Crosby, E. S. Effect of Detergents on Sewage Microorganisms. *Sew. Ind. Wastes*, **25**: 262 (1953).

Technique of Bacterial Examination of Water With Molecular Filter Membranes

Task Group Report

A report of Task Group E5.13—Molecular Filter Membranes. Members of the task group are: Jack E. McKee (Chairman), Ray L. Derby, Alexander Goetz, Ralph E. Noble, and Lee Streicher.

POROUS membranes of cellulose derivatives, developed many years ago by European scientists, were apparently first adapted to sanitary water analysis by the Russians and Germans during World War II as a tentative emergency procedure. In 1947 the method was introduced into the United States by Alexander Goetz at the California Institute of Technology, Pasadena, Calif. (*1*). Subsequently he and his staff developed the molecular filter membrane, which is a basic, improved modification of the European prototype, and they proposed new methods for its application in water bacteriology (*2*). The general availability of these membranes since 1951 has stimulated extensive research and numerous publications (*3–18*).

The purpose of this report is to summarize the present status of such investigations and to outline recommended procedures for bacterial water examination with molecular filter (MF) membranes. In effect, then, this is a procedural paper designed to assist the novice in conducting tests with molecular filter membranes. With this initial report as a guide, the extended application of the MF procedure should lead to further research and many recommendations for improvements.

The evaluation of bacterial concentrations in water by means of the MF technique involves five principal steps: [1] separation of the bacteria (and other suspended matter) from the water sample, and their collection on the upper surface of the MF membrane; [2] impregnation of the membrane with nutrient liquid from a prefabricated pad to provide for total or differential culturing of bacterial colonies; [3] incubation of the MF and nutrient-pad assembly; [4] counting and evaluation of the types of bacterial colonies; and [5] preservation of the MF record. These steps will be discussed in detail following a description of the apparatus, materials, and media commonly employed for the tests.*

Apparatus and Materials

Molecular filter membranes. The commercially available MF membranes for bacterial water examination consist of a highly porous gel of complex cellulose ester polymers. The membranes have a thickness of approximately 150 μ (0.006 in.) and a porosity of 80–85 per cent. Under a differential pressure of 70 cm of mercury at 21°C, they permit a flow rate of

* Some of the apparatus and materials used in the MF procedures are not yet widely available through local chemical supply firms. For this reason, any such special equipment is designated in this report by a small letter in parentheses, which refers to the manufacturer or distributor as listed at the end of the report (p. 1210).

70–80 ml of distilled water per minute through each square centimeter of exposed surface (*3–7*). Two different standard sizes of MF membranes are presently available: a disk 47 mm in diameter, with an effective filter area of 9.6 sq cm; and a disk 86 mm in diameter, with an effective area of 48 sq cm. Inasmuch as membranes of this type expose 300,000,000 to 500,000,000 pore openings per square centimeter on the upper surface, with an effective pore diameter of less than 0.5 μ, they effectively screen out all bacteria from water, so that the effluent is bacterially sterile. The upper face through which the water enters and upon which the bacteria are deposited generally carries an imprinted grid (Fig. 1) that subdivides the area of the disk so that each square equals 1.0 per cent of the effective filtering area for the 47-mm disk and 0.2 per cent for the 86-mm disk, when used with standard apparatus.

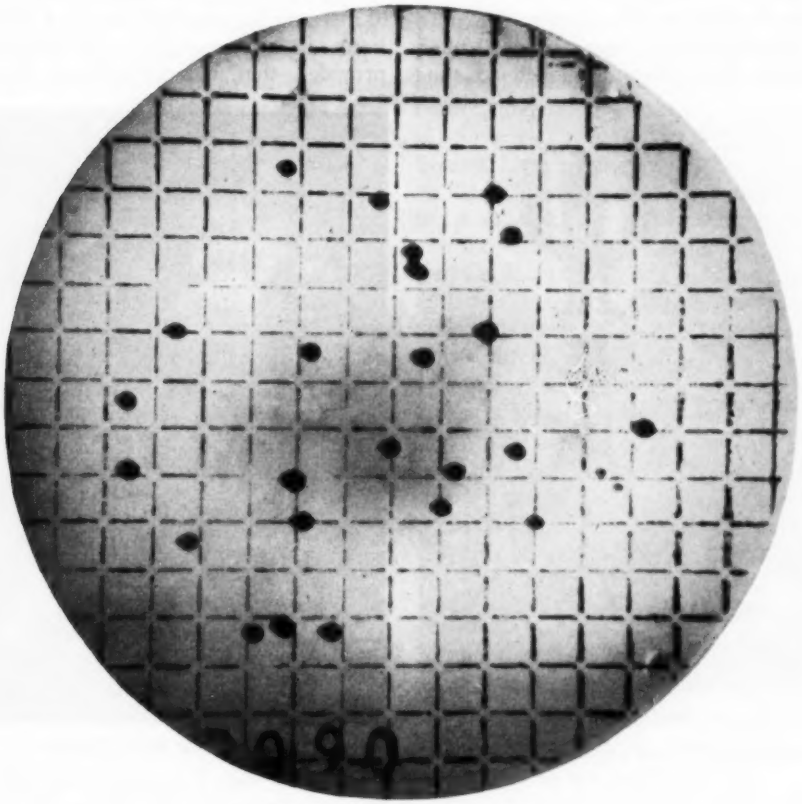


Fig. 1. MF Membrane Grid

Each square equals 1.0 per cent of the effective filtering area for the 47-mm disk, and 0.2 per cent for the 86-mm disk.

Molecular filter membranes of the

type described are commercially available under the trade name "Millipore" (*a*) and as sterile assemblies, with or without prefabricated nutrients, under the trade name "Isopor" (*b*). Imported German membranes with somewhat different characteristics (*8*) are also available in this country (*c*).

Filter holders. Several special filter holders have been developed to support the delicate MF membrane without undue stresses. These holders are integrated with a funnel to contain and measure the liquid being filtered. A stainless steel unit (*d*) with a capacity of 1,000 ml is available for either size of MF disk (Fig. 2), and a pyrex filter holder (*a*) with a capacity of 300 ml is available for the 47-mm disk (Fig. 3). In addition, a special unit (*b*), designed for centrometric filtration of 300-ml samples, as described later, can be used.

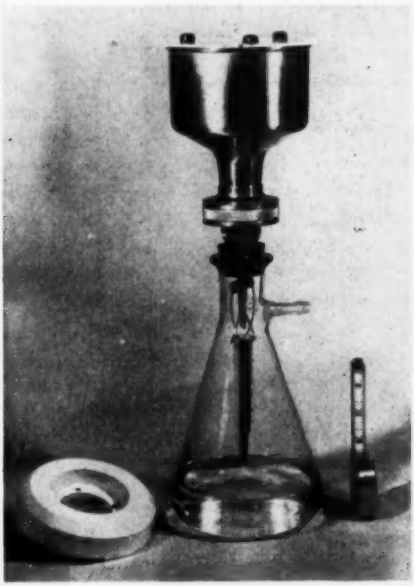


Fig. 2. Stainless Steel Funnel

Units with 1,000-ml capacity are available (d) *for either size of disk.*

Vacuum apparatus. The funnel base is mounted normally on a regular 1- or 2-liter filter flask (see Fig. 2 and 3) connected with a vacuum pump or an aspirator. A vacuum of 10–20 in. of mercury is commonly used for filtration, but any vacuum is satisfactory, provided that it accomplishes filtration in a reasonable time—that is, 1–20 min.

Fig. 3. Pyrex Filter Holder

This holder, with a capacity of 300 ml, is available (a) *for the 47-mm disk.*

Tongs and scissors. The MF membranes should be handled by means of forceps with flat, smooth tips (for example, stamp collectors' tongs). For opening sterile packs of MF membranes and dehydrated nutrient pads, and for cutting membranes into segments to be exposed to different nu-

trients, a pair of small, sharp, high-quality scissors should be available.

Nutrient pads. In American practice, exposed MF membranes containing the filtered bacteria are placed on absorbent pads that are saturated with a liquid nutrient. These pads consist of a circular disk of heavy blotting paper of the same size as the MF. Carefully extracted to avoid the presence of growth-inhibiting agents, dry 47-mm pads have a liquid capacity of approximately 2 ml of nutrient, but slightly more liquid should be added to wet the petri dish and provide capillary tension with it. Dry pads are furnished in conjunction with the commercially available MF membranes, the pads being inserted loosely between membranes. A disk of thin kraft paper protects the MF surface against contamination. (Pads containing prefabricated dehydrated nutrients are described in the section on culture media; see p. 1200). Most differential culturing procedures require contact of the membrane with a sequence of two nutrient pads.

Petri dishes. The 47-mm MF and nutrient pad are incubated in a small standard glass petri dish (60 × 15 mm) or in a plastic disposable petri dish (*a*). The large MF and pad can be incubated in a standard petri dish (100 × 15 mm), but the standard-size dish should not be used for the small MF. Petri dishes with flat bottoms should be selected, and domed dishes must be avoided.

Incubating apparatus. Glass petri dishes containing the MF and nutrient-pad assemblies may be incubated in the conventional humid laboratory incubator as described later in this report. Where this equipment is not available —for example, in a small laboratory or in field tests—the petri dishes may be wrapped tightly in "Parafilm" (*e*) and placed under water in a wide-mouthed vacuum bottle. Plastic disposable petri dishes form tightly sealed MF containers which may be placed in an incubator without further precaution.

Pipets, dilution bottles, and other glassware. Where serial dilutions are indicated, conventional pipets, dilution bottles, and other glassware described in *Standard Methods* (*19*) will be needed. All such glassware must be sterilized prior to use. For the bacterial examination of drinking water or other waters relatively low in bacterial numbers, the size of the sample (50 ml or more) may be measured with sufficient accuracy in a calibrated, sterile filter funnel.

Apparatus and procedures for sterilizing. Molecular filter membranes cannot be sterilized by dry heat. They can be boiled in water, but this procedure is not recommended, because it embrittles the membranes. Sterilization can be accomplished satisfactorily by autoclaving at 15-psi pressure (121°C) for 15 min, provided that the membranes are packed between absorbent pads, wrapped in heavy kraft paper, secured tightly with rubber bands, and placed in the autoclave in a flat position with protection from liquid water.

Another sterilization procedure consists of putting the MF membranes—interspersed with the protective paper disks and with or without pads—in glassine, cellophane, or polyethylene envelopes, sealing the envelopes, and placing them in a large container (such as a desiccator). Liquid ethylene oxide is then added to a small dish in the amount of 0.5 ml for each liter of volume of the container. The dish is placed in the container, which is then

closed. Thereupon the ethylene oxide will evaporate gradually and penetrate the packages, inasmuch as all of the envelopes mentioned are permeable to ethylene oxide. After 3–4 hr in the sterilizing atmosphere, the packages are removed and exposed to air for 24–48 hr in order to avoid any residue of ethylene oxide in the pads or membranes. Sterilized MF and pad assemblies, sealed in polyethylene bags, are commercially available (*b*).

Pads used for nutrients may be sterilized in conjunction with the MF membranes, as described above, or separately in an autoclave. They cannot be subjected to dry sterilization without scorching.

Glass petri dishes may be sterilized by autoclaving at 15 psi (121°C) for 30 min or by dry heat at 170°C for 1 hr. The plastic dishes cannot be sterilized by heat, but they may be reused after ethylene oxide sterilization.

Filter holders (both types) may be sterilized in an autoclave or 170°C oven. The stainless steel funnel and supporting base can be sterilized rapidly and conveniently by means of an alcohol flame or, better still, by the methanol-formaldehyde technique (*9*). The stainless steel unit is supplied with a Lucite plate cap and a sterilizing socket designed so that the funnel base can be suspended in the funnel and placed over the socket (Fig. 4). One or two milliliters of methanol is placed on the asbestos wick and ignited, the funnel is inserted, and the Lucite plate with suspended funnel base is placed *slowly* on the top so as to produce incomplete combustion and the formation of formaldehyde. The closed unit should stand for 15 min, during which the formaldehyde sterilizes all parts of the filtering equipment.

Tongs and scissors can be sterilized effectively, prior to each use, in an open alcohol or Bunsen flame. Any other glass apparatus that may be needed can be sterilized by autoclaving at 15 psi for 30 min or by dry heat at 170°C for 1 hr.

Culture Media

The selection of a culture medium depends upon the purpose of the analysis—that is, whether it is desired to determine total counts, coliform organisms, *Salmonella*, or other specific bacteria. Many of the formulations employed in broth or agar techniques can be used to saturate the nutrient pad, except that two to four times the customary concentrations are needed. Several selective media have been developed especially for use with the MF procedure, and they are being employed successfully on many different types of waters. Space does not permit a complete description of the formulas, applications, advantages, limitations, and methods of employment and evaluation of results of each such medium. Three media are described below and reference is made to other formulations that may be of interest in bacterial water examinations.

General Nutrient for Total Counts

For total counts, or for an enriched period prior to the use of differentiating media, a nutrient consisting of double-strength Albimi M medium with 0.5 per cent lactose, adjusted to pH 7.0 with potassium hydroxide, has been recommended (*4, 5, 7, 10*) and widely used. The formula for this nutrient is:

Albimi M peptone (*f*)	40 g
Yeast autolysate (*f*)	6 g
Dipotassium hydrogen phosphate	3 g
Sodium chloride	5 g
Lactose	5 g
Distilled water	1,000 ml

Adjust to pH 7.0 with potassium hydroxide.

The substitution of dextrose for lactose and the addition of 0.04 per cent TPTZ,* a redox indicator, has also been recommended (*3, 5*). For this modification, dissolve 1 g of TPTZ in 100 ml of distilled water and add 4 ml of this solution to each 100 ml of the basic nutrient. In this noninhibitory concentration, the TPTZ facilitates counting by producing an intense contrast of red colonies against the white MF background.

Endo Nutrient for Coliform Bacteria

Of special significance to the water works and public health professions is

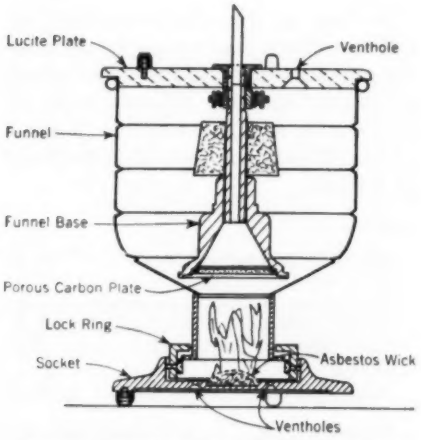


Fig. 4. Stainless Steel Unit Assembled for Sterilization

The base of the apparatus is screwed from below into the plate and hangs freely suspended within the funnel.

the determination of coliform concentrations, inasmuch as these indicator organisms form the basis of the U.S. Public Health Service Drinking Water Standards (*20*). Extensive tests at the USPHS Environmental Health Center (EHC) have indicated that certain types of modified Endo media give results with the MF technique that are comparable to the "confirmed test" of *Standard Methods*.

The major problem in developing such a differential medium is to provide nutrients that will encourage the growth of all coliform organisms with distinguishing characteristics and at the same time suppress the development of as many noncoliform organisms as possible, inasmuch as they might inhibit or alter the growth of the former. This objective is accomplished to a fair degree by a fuchsin-sulfite inhibitor (Endo). For this purpose, the EHC proposed originally (*4*) a broth prepared as follows:

Basal Medium

Lactose	20 g
Neopeptone (*h*)	20 g
Dipotassium hydrogen phosphate	7 g
Distilled water	1,000 ml

Dissolve the constituents in the water, using moderate heat if necessary, and adjust to pH 7.5 with potassium hydroxide solution. Tube this solution in 30-ml portions and autoclave for 15 min at 15-psi pressure.

Sodium Sulfite Solution

Add 9 g of anhydrous sodium sulfite to 100 ml of sterile distilled water.

Basic Fuchsin Solution

Basic fuchsin	3.0 g
Ethyl alcohol	50 ml

Dissolve the dye in the alcohol and then add sufficient distilled water to make 100 ml. Store this solution in the refrigerator to reduce evaporation of the alcohol.

Add 1.0 ml of the sodium sulfite solution and 1.0 ml (or the amount indicated by the titrations described in the next paragraph) of the basic fuchsin solution to a 30-ml tube of the basal medium. Mix thoroughly. This mixture should be used the day it is prepared.

Because the basic fuchsin may differ in dye content from lot to lot and

* Triphenyltetrazolium chloride (*g*).

the fuchsin-sulfite ratio is very critical in the finished nutrient, it is necessary to standardize the proportion of basic fuchsin to sodium sulfite with each new lot of dye. This is done by running parallel MF determinations on a coliform-polluted water, using 0.6, 0.8, 1.0, 1.2, 1.4 ml, and so on, of fuchsin solution along with 1.0 ml of sodium sulfite solution in the 30-ml tubes of basal medium, to determine which concentration of fuchsin gives the optimum growth and best metallic sheen. A dehydrated form of the EHC modification of Endo broth, in which the ingredients have been standardized, is available commercially (*i*).

Selective media, such as the Endo nutrient, have an inhibiting action that may suppress the growth of coliform bacteria unless they are already in an active phase of growth. Accordingly, the EHC recommends that an exposed MF membrane be incubated for 2 hr at 35°C on a pad containing the general nutrient and then transferred to an Endo pad for 14 hr.

This Endo nutrient was subsequently considered by the EHC staff to be inadequate for untreated waters having either a high noncoliform density with relatively few coliform bacteria or a large population of bacteria that ferment lactose with the production of acid but not gas. To overcome this inadequacy, a medium containing ethyl alcohol (3.0 per cent) and brilliant green (0.00025 g per milliliter), in addition to the ingredients in the regular Endo nutrient, was developed and designated "BGF Medium" (*11, 12*). More recently, a medium employing oxine * in addition to the regular Endo nutrient has been proposed (*13*). To each 30 ml of the basal medium described above, 8.0 ml of a stock solution containing 100 ppm of oxine is added. To this mixture, an amount of the fuchsin-sulfite solution, as determined by the standardization procedure, is then added.

Further research to develop the Endo medium is being conducted and may result in improvements to assist in differentiating coliform from noncoliform bacteria. This problem is discussed in more detail later in the report (see section on counting and evaluation, p. 1208).

EMB Medium for Differentiation

In lieu of the Endo nutrient, an EMB medium can be used to inhibit the growth of noncoliform bacteria and to assist in the differentiation of *Escherichia* and *Aerobacter* organisms (*14*). This liquid nutrient is prepared as follows:

Solution A

Albimi M peptone (*f*)	40 g
Yeast autolysate (*f*)	6 g
Dipotassium hydrogen phosphate	7 g
Sodium chloride	5 g
Bacto bile salts No. 3 (*h*)	1 g
Lactose	20 g
Distilled water	1,000 ml

Adjust to pH 7.4 with potassium hydroxide, tube in 30-ml portions, and autoclave for 15 min at 15-psi pressure.

Solution B

Two grams of methylene blue in 100 ml of sterile distilled water.

Solution C

Eight grams of eosin in 100 ml of sterile distilled water.

To each 30-ml tube of Solution A add 1.5 ml of Solution B and 2 ml of Solution C; mix thoroughly and use on the day of preparation. In addition, the MF membranes should be pre-dyed by gentle boiling for 10 min in a 0.5 per

* 8-hydroxyquinoline, a mild cationic agent that is reported to exert a more effective inhibition on Gram-positive organisms than on Gram-negative ones.

cent solution of methylene blue. Excess dye is removed by gentle boiling in two changes of distilled water for 5 min each.

Like the Endo nutrient, the EMB medium has an inhibiting action upon coliform bacteria unless the organisms are already in the active growth phase. For this reason, the exposed MF should be incubated for 2 hr at 35°C

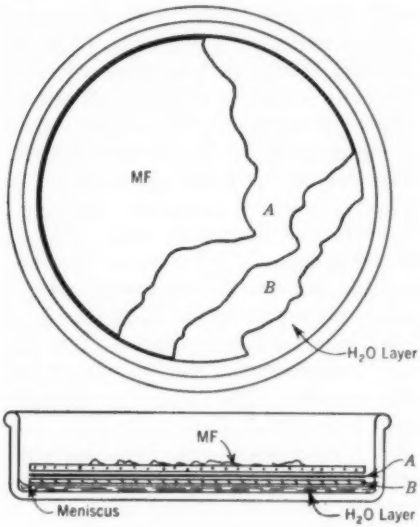


Fig. 5. Dehydrated-Nutrient Pads

Pad A *is impregnated with a dehydrated enrichment nutrient, while Pad* B *contains the dehydrated inhibitory or differentiating medium.*

over a nutrient pad containing an enrichment medium similar to the general medium previously described.

Other Differentiating Media

German bacteriologists have employed successfully a Gassner nutrient (*5*) for indicating lactose-fermenting bacteria, but attempts to use this formula in the United States have been discouraging, inasmuch as the exact German dye substances were not available.

For the isolation of typhoid bacteria (*Salmonella typhosa*) on the MF, a bismuth-sulfite (Wilson-Blair) broth is an excellent medium (*10*). The conventional formula (*15*) is used in double strength, with the agar omitted. Preliminary enrichment is unnecessary and undesirable.

Brilliant green broth has been employed successfully to differentiate coliform, *Salmonella,* and *Shigella* organisms, following a preliminary enrichment on tetrathionate nutrient (*10*).

Dehydrated-Nutrient Pads

For the convenience of small laboratories and for use in field determinations, pads containing the required concentration of dehydrated nutrients are available (*b*). These nutrient pads, supplied in units of two or six impregnated pads and two or six MF membranes in a sterile package, require only the addition of distilled water. For total counts, the single pads are impregnated with the general nutrient, fortified with TPTZ and containing dextrose in lieu of lactose.

To eliminate the transfer procedures required with enrichment media for the Endo and EMB nutrients, dehydrated-nutrient schedules have been developed (*9*). These nutrient schedules comprise two pads (Fig. 5): a thin leaf of an absorbent, porous paper (Pad *A*) overlying a heavier disk of blotting paper (Pad *B*). Pad *A* is impregnated with a dehydrated enrichment nutrient, whereas Pad *B* contains the dehydrated inhibitory or differentiating medium. Upon rehydration with distilled water, the nutrient in the upper leaf diffuses through the MF and provides an immediate stimulus for all of the organisms. At the

same time the differentiating nutrient in Pad *B* begins to diffuse into Pad *A*, gradually saturating it with the inhibitory substance. By the time the selective medium has saturated Pad *A* and starts to diffuse through the *MF* to the bacteria, a sufficient period has elapsed for the organisms to reach the active growth phase. Such dehydrated-nutrient schedules are available as Endo, EMB, and other formulations (*b*).

Handling of Samples

When the MF technique is employed, samples should be collected, stored, and transported in accordance with the sampling procedure and precautions described in *Standard Methods* (*19*). When dilutions are required, they should be made in conformity with *Standard Methods*. The MF techniques hold an advantage over conventional methods, however, in that they are more adaptable to field determinations, thereby minimizing the delays caused by transportation and storage. Methods for use in the field or in small laboratories are described later in this report.

Filtration

To carry out the first step in the MF technique—the separation of the bacteria from the water sample and their collection on the surface of the membrane—mount the sterile funnel base on a filter flask connected to a vacuum pump or to a water tap aspirator, but do not apply the vacuum until after the sample has been added to the funnel. By means of sterile tongs, carefully remove an MF membrane with its protective disk from the sterile package and place it, with grid side up, on the porous disk, being careful that the MF fits into the circular recess of the funnel base. As the paper disk can be touched by hand, the MF can easily be put in the proper position, after which the disk is removed. Assemble the funnel by means of the locking device, being careful to avoid undue force or pressure. The apparatus and MF membrane are now ready for filtration.

Pour the sample of water being tested into the funnel. The sample may be measured in a sterile graduated cylinder, or, if it consists of 50 ml or more, it may be measured with sufficient precision in a calibrated funnel. With the sample in the funnel, apply a vacuum of 10–20 in. of mercury. The sample will filter rapidly in a few minutes unless it contains a high concentration of suspended solids. When the MF appears dry, remove the funnel and number the membrane with a ballpoint pen along the clean edge that was protected from filtration. Do not use a conventional pen or pencil for this purpose. The vacuum in the flask will keep the MF in position. The MF is now ready to be removed with sterile tongs and placed upon a previously prepared nutrient pad.

Selection of Sample Quantity

Selection of the quantity of water to be filtered is a matter of considerable importance. If too many organisms—more than 500—are retained on the membrane, confluent growths develop and counting becomes difficult or inaccurate. On the other hand, if only one or two bacteria are retained, the count becomes statistically unreliable. Consequently, it is important that the quantity of water to be filtered contain at least three, but not more than 300, bacteria of the type being cultured.

For drinking water that is expected to comply with USPHS standards

and thus contain an average of not more than one coliform organism per 100 ml, the filtration of a volume between 300 and 500 ml should provide an ample margin of safety. One such quantity should be equivalent in precision to presumptive tests in lactose broth with 30–50 tubes of 10 ml each.

It is not feasible to filter less than 10 ml through a 47-mm MF membrane. Hence, if raw waters containing more than 3,000 coliform bacteria per 100 ml are to be tested, dilution of 10 ml of the original sample in 990 ml of sterile dilution water is recommended, and this procedure may have to be repeated if higher dilutions are necessary. The dilution schedule in Table 1 has been recommended (*16*) because it results in a maximum range of information with the least number of filtration steps that overlap each other sufficiently to be reliable.

TABLE 1

Recommended Dilution Schedule

Step	Dilution	Recommended Sample Size *ml*	Countable Range of Bacteria per 100 ml	Typical Application
A	none	300	0.3–100	treated water
B	1:100	200	50–15,000	raw water
C	1:10,000	100	10,000–3,000,000	treated sewage
D	1:1,000,000	100	1,000,000–300,000,000	raw sewage

Selection of MF Size

For the analysis of drinking water and relatively clear raw water, the 47-mm MF is generally adequate. Turbid surface waters, high in suspended solids and relatively low in coliform organisms, tend to form on a small MF a surface deposit in which bacteria are imbedded. This deposit can produce serious deviations from normal growth habits, rendering the colonies indistinguishable or difficult to evaluate on differentiating media. Reduction of the sample volume to minimize the deposit restricts the MF application for turbid waters to those that contain high bacterial concentrations. For waters high in suspended solids and low in bacteria it is recommended that the 86-mm MF be used (*9*). This membrane has an exposed area five times that of the small MF, and, hence, the surface deposit will be one-fifth as thick, with a corresponding increase in the reliability of the results.

Concentrometric Filtration

An ingenious device, known as a "Concentrometer," has been developed recently (*17*) to facilitate the use of the MF membranes with waters in which the bacterial densities cannot be estimated beforehand within a factor of 100. This apparatus extends the range of reliable bacterial counts to a ratio of better than 1 : 50,000. A rectangular MF membrane, mounted on a frame with a preprinted scale, forms one vertical side of a specially designed container holding 300 ml of sample. When a vacuum is applied, the sample is drawn horizontally through the membrane in such a manner that each horizontal MF section passes a different quantity of sample, ranging from 0.1 ml for the uppermost

edge to 300 ml for the entire MF. The volume that passes through each horizontal section increases logarithmically with depth, as designated by the preprinted scale, owing to the special shape of the container. Consequently, the density of colonies on the incubated membrane will vary logarithmically, and at some point along the scale the density will be both countable and reliable.

Application of Nutrient

If liquid nutrient, small MF membranes, and plain pads are being used, pipet 2.2–2.4 ml of the nutrient into a sterile half of a 60 × 15-mm petri dish, and then, by means of sterile tongs, place a plain pad on the liquid. For the large MF pad, use 6.5–7.0 ml and a 100-mm dish. The pad should become completely saturated with liquid, and a slight excess of liquid should be visible around the periphery of the pad. Cover this dish with the lid of a larger petri dish until the pad is ready to receive the MF membrane.

If dehydrated-nutrient pads are being used, pipet 2.2–2.4 ml of sterile distilled water into the petri dish and add the dehydrated-nutrient pad in the manner described above. Rehydration takes place in a few seconds. When nutrient schedules are used, the colored side of the assembly should be placed on the bottom of the dish.

With sterile tongs, carefully remove the MF membrane from the funnel base and place it, with the grid side up, on the wet nutrient pad, using a rolling motion to assure that no air is trapped between the membrane and the pad. Liquid nutrient from the saturated pad can now diffuse through the MF membrane and become available to the bacteria retained on the grid side. Any excess liquid should be drained by slowly turning the dish upside down, being careful to avoid contact between the liquid and the MF surface.

Incubation

For the MF technique, temperatures of incubation are the same as in conventional procedures, but incubation periods are generally shorter. Any of the following procedures, or logical combinations thereof, may be used for incubation of the MF and nutrient-pad assemblies. Whatever the procedure, it is important to be sure that incubation takes place in an atmosphere of saturated humidity, to prevent dehydration of the assembly.

Pyrex trays in laboratory incubator. Insert a wet towel in the bottom of a large pyrex baking dish and keep this tray in the laboratory incubator until it is needed. When MF and nutrient-pad assemblies are ready for incubation, invert the glass petri dishes on the towel (see Fig. 6) and replace the tray in the incubator. Nutrient pads and MF membranes will cling to the upper glass surface. This inversion is necessary so that drops of condensed water will not fall upon the MF membrane and cause colonies to coalesce.

Covered glass petri dishes in laboratory incubator. Using the bottom half of a petri dish for the MF and pad assembly, put a larger disk of filter paper or blotting paper (nonsterile) in the lid, saturate it with water, invert the bottom half of the petri dish, and place it on the wet paper in the lid.

Plastic disposable petri dishes in laboratory incubator. These dishes are supplied with a cover that should be secured tightly before the dishes are inverted and placed in the incubator. The tight cover stops the escape

of moisture, and inversion is necessary to prevent condensed droplets from falling on the MF membrane.

Film-sealed glass petri dishes in laboratory incubator. A plastic film—such as Parafilm (*e*)—that is pliable, moistureproof, and adhesive to the glass rim can be molded tightly around the open face of a petri dish to seal it effectively against the escape of moisture or the introduction of contaminants. One side of the film is covered with a protective paper to assure a sterile surface. Peel off the protective paper and stretch the film over the rim of the petri dish, with the sterile side of the film facing the MF membrane. Fold the edges smoothly around the dish, invert it slowly, and place it in the incubator.

Film-sealed glass petri dishes in wide-mouthed vacuum bottle. Recent tests (*16, 18*) have shown that MF and nutrient-pad assemblies in Parafilm-sealed dishes can be incubated successfully in a wide-mouthed vacuum bottle equipped with a rack to facilitate the insertion and removal of the dishes. For the determination of coliform organism and total counts, the vacuum bottle should be filled with water at 38°–40°C for at least 15 min prior to use. Remove the rack from the vacuum bottle, stack the inverted film-sealed dishes in the rack, and immerse it in the bottle. If necessary, refill with water at 38°C. For tests at 20°C, use water of this temperature to prepare the vacuum bottle and to refill it.

The fact that the temperature in the vacuum bottle may drop slowly during the incubation period is not detrimental to the culture of coliform organisms.

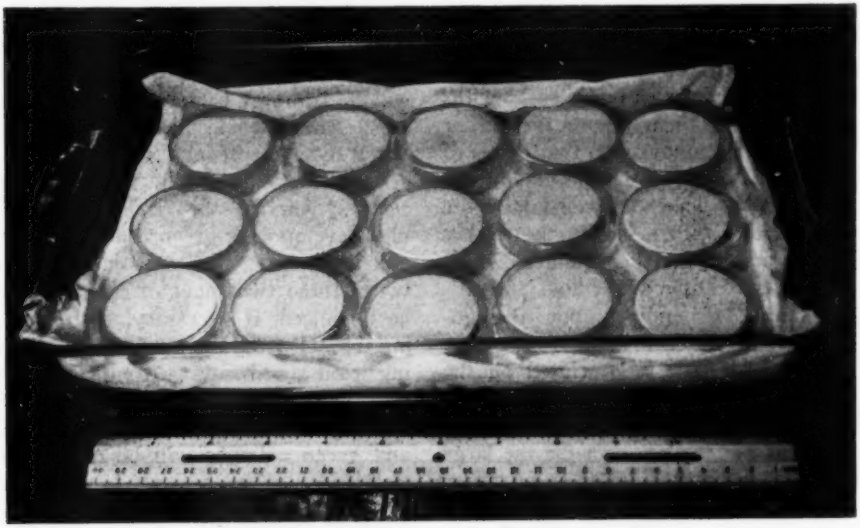


Fig. 6. Pyrex Tray Used During Incubation

Inverted glass petri dishes are placed on a wet towel in the tray, which is an 8½ × 13-in. pyrex baking dish.

Indeed, this drop may be beneficial, inasmuch as the sought-for organisms are initially stimulated by optimum temperatures and specific media and then slowly retarded by dropping temperatures. This diminution of the rate of growth discourages the formation of excessively large colonies and their possible confluence.

Counting and Evaluation

Upon completion of the incubation period, which extends from 10 to 20 hr for most bacteria of interest in water analyses, take the dishes from the incubator or vacuum-bottle rack, without inverting them before the lid or film cover is removed, so that drops of water that may have collected on the covers of the dishes will not fall on the membrane. Then invert the dishes slowly and count the colonies, which should be readily discernible and differentiable, depending upon the nutrient that has been used.

The grid pattern imprinted on the MF membrane divides the surface into squares, each of which represents 1 per cent (or 0.2 per cent for the large MF) of the area exposed to filtration. Consequently, if more than 50 colonies are present, count the number in five or ten typical squares, calculate the average count per square, and multiply by 100 (or by 500 for the large MF).

If an Endo medium has been used, the coliform organisms will appear on the purplish-red membrane as colonies with a golden metallic reflection after 10–12 hr of incubation at 37°C. The visibility of the sheen is best when illumination is nearly perpendicular to the MF surface. Colonies of other organisms that are not completely inhibited by the fuchsin-sulfite medium will appear without sheen. When membranes are allowed to dry, the sheen is sometimes more readily discernible to the inexperienced observer. It is therefore recommended that counts be made for both the wet and dry conditions, until facility in recognizing the colonies is attained. When a heavy "background" growth tends to interfere with the proper formation of metallic sheen, one of the modified Endo formulas (such as BGF or oxine) or scheduled nutrient pads should be tried.

When the EMB medium has been used, most of the colonies that appear will be coliform bacteria, inasmuch as most other bacteria are inhibited. After 18–24 hr of incubation, the *Aer. aerogenes* colonies will have orange centers, whereas the *Esch. coli* colonies develop dark-green centers with a metallic lustre. The distinction between these two types of colonies can be enhanced, if necessary, by removing the MF from the nutrient and placing it on a pad saturated with a 2 per cent methylene blue solution. After 15 min the contrast between orange and green colonies will be quite distinct.

Preservation of MF

One of the major advantages of the MF technique lies in the fact that the membranes can be used as permanent records. After the incubation has been terminated and the colonies have been counted, remove the membrane from the nutrient pad with tongs and place it on a piece of white paper, such as blotting paper, for drying. Do not place the wet membrane on colored paper, for the dyes may alter the color or other aspects of the colonies. If the membrane is suspected of carrying pathogenic bacteria, place it on filter paper containing a 5–10 per cent

solution of boric acid. Contact with this pad will kill all colonies in a few minutes without changing their appearance. Next, place the dry MF membrane for 15–30 min on a pad containing a 15 per cent glycerin solution, to enable the membrane to remain permanently flexible. Thereafter it can be mounted with rubber cement on index cards or in a book as a permanent record.

In a properly constituted Endo nutrient, the metallic sheen will remain after drying; in fact, the coliform bacteria colonies may be more readily distinguished from the other colonies after such drying. With the EMB nutrient, however, the distinction between *Esch. coli* and *Aer. aerogenes* colonies disappears upon drying, and, therefore, the evaluation and counting should be done while the membrane is wet. The distinction will reappear if the dried membrane is moistened again.

Adaptability of Technique

The simplicity and rapidity with which the MF technique is endowed make it particularly adaptable for field work and for small water works laboratories that are not equipped for conventional bacteriology. These adaptations include, but are not necessarily limited to:

1. Sterile packages of MF membranes and dehydrated-nutrient schedules, which eliminate the need for sterilization of membranes and the preparation of fresh nutrient.

2. Plastic disposable petri dishes; sterile when received and first used, these dishes may be discarded, or saved and used again after sterilization with alcohol or ethylene oxide.

3. Methanol-formaldehyde sterilization of the entire filtration equipment; glass petri dishes can be placed in the funnel and sterilized in a similar manner.

4. Incubation in vacuum bottles or even by body heat, in a tight-fitting jacket or vest, rather than in a constant-temperature incubator.

These adaptations, and others, have been incorporated in one compact, self-contained, portable bacteriological laboratory (*16*) which is commercially available (*b*).

References

1. Goetz, Alexander. Materials, Techniques, and Testing Methods for the Sanitation (Bacterial Decontamination) of Small-Scale Water Supplies in the Field, Used in Germany During and After the War. Fiat Final Rpt. 1312, Joint Intelligence Objective Agency, Washington, D.C. (Dec. 1947).
2. Winslow, C.-E. A. The Role of the Molecular Filter Membrane in the Field of Public Health (Editorial). *Am. J. Pub. Health*, **43**:766 (1953).
3. Goetz, Alexander, et al. Early Detection of Bacterial Growth. Final report of research carried out by California Inst. of Technology for Biological Dept., Chemical Corps, U.S. Army, in fulfilment of Contract W-18-064-CM-207 (July 1951).
4. Clark, H. F., et al. The Membrane Filter in Sanitary Bacteriology. *Pub. Health Rpts.*, **66**:951 (1951).
5. Goetz, Alexander & Tsuneishi, Noel. Application of Molecular Filter Membranes to the Bacteriological Analysis of Water. *Jour. AWWA*, **43**:943 (Dec. 1951). Kabler, P. W.; Streicher, Lee; & Neumann, H. G. Discussion. *Ibid.*, p. 969.
6. Bush, J. H. New Bacteriological Technique for Testing Water and Sewage. *Wtr. & Sew. Wks.*, **100**:151 (1953).
7. Clark, H. F. & Kabler, P. W. The Membrane Filter in Water Quality Tests. *Am. J. Pub. Health*, **42**:385 (1952). Goetz, Alexander. Discussion. *Ibid.*, p. 389.
8. Clark, H. F., et al. Domestic and European Molecular Filter Membranes. *Jour. AWWA*, **44**:1052 (Nov. 1952).

9. GOETZ, ALEXANDER; GILMAN, R. H.; & RAWN, A M. Application of Molecular Filter Membranes to Specific Problems in Water Analyses. *Jour. AWWA,* **44**:471 (June 1952).
10. KABLER, P. W. & CLARK, H. F. The Use of Differential Media With the Membrane Filter. *Am. J. Pub. Health,* **42**:390 (1952).
11. *USPHS Environmental Health Center Activity Rpts.,* No. 15, p. 17 (Jan.–Mar. 1953).
12. *USPHS Environmental Health Center Activity Rpts.,* No. 16, p. 13 (Apr.–June 1953).
13. YEE, G. S.; KRABEK, W. B.; & SCHAUFUS, C. P. A New Medium for the Bacteriological Analysis of Water With the Membrane Filter. *Jour. AWWA,* **45**:945 (Sept. 1953).
14. *USPHS Environmental Health Center Activity Rpts.,* No. 14, p. 13 (Oct.–Dec. 1952).
15. *Difco Manual.* Difco Labs., Inc., Detroit (8th ed., 1948).
16. GOETZ, ALEXANDER. Application of Molecular Filter Technique to the Bacterial Assay of Sewage. *Sew. Ind. Wastes,* **25**:1136 (1953).
17. ———. The Concentrometer Method of Applying Molecular Filter Membranes. *Jour. AWWA,* **45**:933 (Sept. 1953).
18. TSUNEISHI, NOEL & GOETZ, ALEXANDER. Growth Development of Bacterial Cultures of Molecular Filter Membranes. *Proc. Soc. Am. Bacteriologists,* p. 26 (1953).
19. *Standard Methods for the Examination of Water and Sewage.* Am. Pub. Health Assn. & Am. Water Works Assn., New York (9th ed., 1946).
20. Drinking Water Standards. *Pub. Health Rpts.,* Reprint No. 2697 (Mar. 15, 1946); *Jour. AWWA,* **38**:362 (Mar. 1946).

List of Manufacturers

a. Lovell Chemical Co., 36 Pleasant St., Watertown 72, Mass.
b. AG Chemical Co., Box 65C, Pasadena 6, Calif.
c. Schleicher & Schuell Co., Keene, N.H.
d. Leslie R. Burt Co., 540½ W. Fairview Ave., Arcadia, Calif.
e. Marathon Corp., Menasha, Wis. (The plastic film produced by this firm has been tested extensively for the purpose described. Other, similar films with comparable qualities may possibly be available, but they should be tested carefully for moisture-tightness and toxic vapors.)
f. Albimi Labs., Inc., 16 Clinton St., Brooklyn 2, N.Y.
g. Synthetical Labs., Chicago.
h. Difco Labs., Inc., Detroit 1, Mich.
i. Marketed by Difco Labs. as "Bacto M–Endo Broth, Dehydrated."

The Problem of Public Employee Safety

By Wendell R. LaDue

A portion of a paper presented on Apr. 15, 1953, at the All-Ohio Safety Congress, Columbus, Ohio, by Wendell R. LaDue, Chief Engr. and Supt., Bureau of Water and Sewerage, Akron, Ohio.

PUBLIC employees, from the federal to the municipal level, represent the largest single group in the United States not subject to formal safety standards, regulations, and programs. Fortunately, there are cities which are outstanding exceptions to this general statement, but all municipalities must realize that they are obligated to do everything within their power to prevent accidents and attendant suffering among their employees.

Most of the successful accident prevention programs in operation today are carried on by large private employers. The reasons for this situation are too complex for extended discussion in this paper, but some of the obvious factors are: pressure of competition, centralized control and authority, modern cost-accounting systems, legislative provisions, and union demands. The fact is, big industry—private industry—has a virtual monopoly on permanent and effective safety work. Small industry, however, must and will learn that safety programs are good business. Moreover, they make for good employee and public relations and provide protection against legislative control.

Municipal agencies, like small industrial plants, have been slow to grasp the relationship of active safety programs to economy and efficiency of operation. Apathy on the part of cities can be changed to lively interest chiefly through positive decisions by the executive heads of the government involved. It is an axiom in the safety field that an organization has no more employee injuries than top management will allow. If top management shows no regard for the safety of its employees, unsafe conditions will breed accidents.

This view may seem to place an undue burden on management, but it must be recognized that a good safety program is part and parcel of the overall problem of conducting a successful business. It is just as important as producing a salable article, selecting a suitable factory site, or purchasing the necessary tools, equipment, and materials. A positive stand on safety by the chief executive of a state or municipality will, of course, be translated into an equally active interest on the part of supervisors, by means of training, upgrading, persuasion, and other conventional devices for carrying out executive orders.

A safety program can be applied even by the small city which cannot afford a safety director. Safety is not necessarily a specialty; it is largely a matter of common sense. Almost any competent administrator or depart-

ment foreman knows enough about the job to get it done right, and safety, in its essence, simply means performing an operation correctly, under proper control. Such control applies also to persons and their potentially unsafe acts. It is part of the plan of procedure.

Small cities are not doomed to have high injury rates. They stem from failure to act rather than from inherent difficulties. This statement has been proved many times by the success achieved by small enterprises in controlling accidents when the administration recognized the problem, analyzed the causes, developed a solution, and acted vigorously and intelligently.

The principles underlying a municipal safety program are the same for all cities, regardless of size. It may, therefore, be of interest to describe the workings of an actiual program in a city with which the author is familiar.

Akron Program

The Akron, Ohio, safety program has grown progressively more active over the years since its inception in 1938. Each municipal division and department is responsible directly to the mayor. By direct delegation of orders and authority, the department head passes responsibilities to the division heads, who, in turn, hold all supervisory personnel responsible for direct worker contact. Safety activities are coordinated through the safety and claims division of the department of personnel, Civil Service Commission. Heading this division is a trained full-time employee, with the title of "Safety and Claims Examiner." The status of the city's safety effort is reported through his office to the departments and divisions and to the mayor. The examiner's duties cover all activities of the city—administration, police, fire, water supply, sewerage, parks, and highways—and he deals, in general, with the responsible supervisory heads. His concerns include:

Departmental safety news. A 4–8-page pamphlet is distributed monthly to all employees. It contains inspirational, informative, and statistical material, of both general and specific interest. To create a widespread spirit of rivalry, comparative and relative safety standings are given for each division.

Safety contests. Safety contests are promoted as the occasion warrants. "White Elephants" and "Behind-the-Eight-Ball" trophies are presented for serious deficiencies. Awards for meritorious ratings balance the effort and the reaction.

Training programs. From time to time it is found beneficial to conduct training courses for supervisory personnel. Such courses are essential to keep supervisors abreast of new developments or processes. Civil defense training has become an important part of this effort, and all supervisory personnel have been trained in standard first-aid methods.

Safety organizations. As a member of the American Society of Safety Engrs., the safety and claims examiner is kept fully informed of national progress in the safety field. He affiliates himself with local and state sections. Attendance at local safety conferences, particularly those held by industry, affords an opportunity for cooperative effort and mutual understanding of kindred problems.

Relative statistics. Using standard methods, the "safety man" compiles statistics for the various city subdivisions, listing relative standings in accident severity and frequency. Such

data provide a valuable comparison with those few cities that conduct safety programs on the same high level.

Compensation claims. Ohio has a compulsory workmen's compensation law. In proportion to the severity of its accidents, the city must pay its just share of the expense involved in administering the act. The value of properly prepared papers and accurate statistics is at once apparent. The monetary value of accident reduction is also evident. The "safety man" clears all workmen's compensation papers through his office, and, with the aid of the law department, acts as the city's agent in matters involving the compensation law.

Safety inspections. In conjunction with a representative of the Ohio Industrial Commission, periodic inspections of the city's work areas are made. A report is prepared and given to the mayor, with copies to department heads. All violations of working conditions are cited, with recommendations for correction. A repeated violation draws a sharp but earned rebuke.

Safety Program Elements

As part of their training, all supervisors are required to learn how to proceed in cases of injury. A knowledge of first aid is therefore essential. General instructions by the division head are given from time to time as new ideas or needs develop.

It is highly important in any program to know what happened and why it happened. A preliminary report describing the circumstances of the accident and the nature of the injury is made out and telephoned to the division office immediately after an accident involving injury. Much time was spent in developing the form (Fig. 1a and 1b) on which the supervisor reports the case. This form is worthy of close examination. It does not attempt to place blame, but is a concise record of what happened and requires the supervisor to state why an accident happened and what can be done to prevent its recurrence. This form, fully filled out, must reach the safety and claims office within 48 hr of the time of the injury.

The best surgeons in the city are made available to the injured employee. He has the obligation, however, of presenting himself for treatment of all reported injuries. Constant check of injured employees is maintained by their supervisors upon the advice of the attending physician.

Medical examination is important in the filing of workmen's compensation claims, which the employee is obligated to do. The safety and claims office aids him by securing a statement from the attending physician, reviewing it, and then forwarding it to the Ohio Industrial Commission. Employees know that claims are handled by the commission as individual matters and learn to respect its helpfulness. In questionable or contested claims, the safety and claims examiner represents the city before the district board of claims or before the state commission.

Many protective devices, such as goggles, gloves, masks, and gas detectors, are furnished by the city. In some processes, protective devices are a necessity in order to carry out certain instructions. The employee may go beyond these essentials to protect himself further. Proper connections are maintained to enable personnel to secure eye examinations and safety prescription glasses at reduced rates. Advice and encouragement are given

FOR FILE USE ONLY
No.
Date Rec'd
Claim M'l'd

1. Department ..... Division .....
2. Injured Employee .....
3. Address .....
4. Age ..... Social Security Number ..... Married, Single, Widowed, Divorced .....
5. Number and relationship of dependents .....
6. Where did accident occur? .....
7. When did accident occur? ..... 195..... ..... A. M. ..... P. M.
8. Did employee quit work? ..... When? ..... 195..... ..... A. M. ..... P. M.
9. Has employee returned to work? ..... When? (Give last date worked) ..... 195..... ..... A. M. ..... P. M.
10. Name and address of witnesses .....
11. Experience of employee in this type of work during life time? ..... Years ..... Months
12. Name of job or product employee was working on and nature of work when accident occurred .....
13. What machine, tool, substance or object was most closely connected with the accident? .....
14. How did accident occur? (Give as many facts as possible) .....
15. Describe in detail the nature of the injury and the part of the body affected .....
16. Name and address of physician .....
    Name and address of hospital .....
17. Circle cause or causes you believe were involved in this accident.

PERSONAL FAULTS

A. Faulty Instruction
1. None 3. False
2. Incomplete

B. Inability of Employee
1. Inexperience 2. Unskilled
3. Poor Judgment

C. Poor Discipline
1. Disobedience of rules
2. Interference by others
3. Horseplay

D. Lack of Concentration
1. Attention distracted
2. Inattention

E. Unsafe Practice
1. Chance taking
2. Short Cuts
3. Haste

F. Mental Condition
1. Sluggish or fatigued
2. Violent temper
3. Excitability

G. Physical Condition
1. Defective 2. Tires easily
3. Weak

MECHANICAL & MATERIAL FAULTS

H. Hazards of Work
1. Weather 2. Road conditions

I. Poor Housekeeping
1. Improper piling or storing
2. Crowded conditions
3. Failure to keep job clean

J. Defective Equipment
1. Tools 2. Vehicles
3. Safety Equipment
4. Miscellaneous

K. Unsafe Building Conditions
1. Floors
2. Vehicles
3. Openings
4. Miscellaneous

L. Improper Working Conditions
1. Ventilation
2. Sanitation
3. Light

M. Improper Planning
1. Failure to provide proper tools
2. Unsafe process
3. Miscellaneous

N. Improper Dress or Apparel
1. No eye protection
2. No safety shoes
3. Miscellaneous

NOTICE—Original and First Copy of this report must be forwarded to Division in charge of Personnel Safety within 48 hours after accident. Answer questions fully. Additional remarks may be made on reverse side.

(OVER)

Fig. 1a. Supervisor's Report of Injury

the employees in the procurement of safety clothing and, in particular, safety shoes. The supervisors set the example.

Excellent results may be obtained through the consistent, but not boring, use of safety literature, posters, and handbills. Outstanding efforts are

What action do you recommend to prevent reoccurrence of this type of injury?.....

.....

What steps have you taken to carry out these recommendations? .....

.....

Signature of Immediate Supervisor.....

Date.....195..... Title.....

In Case of Strain or Hernia Answer These 5 Questions

1. Weight of object handled (Approx.)..... 2. How high lifted?.....
3. Was this an unusual strain?..... 4. Did injury appear suddenly?.....
5. Has employee ever complained of similar injury?.....

Division Head's Report

Do you agree with Supervisors choice of cause?.....

If not to what cause do you attribute this injury?.....

Notice the supervisors recommendation to prevent reoccurrence. Do you have any further remarks?.....

.....

.....

.....

.....

This report forwarded.....195.....

(To be signed by Division Chief) Signature .....

Title.....

Remarks: .....

.....

.....

Fig. 1b. Supervisor's Report of Injury (Reverse)

made along these lines, with continual reliance on material furnished by the National Safety Council and the Ohio Industrial Commission.

Akron is proud of the fact that it was one of the first cities in the United States to take advantage of the new, comprehensive "public employees membership" privileges afforded by the National Safety Council. Akron also participated fully in the studies and activities leading to the establishment of the public employee section of the National Safety Council. The value of this organization to the city's safety program continues to grow.

General Safety Advisory Committee

The activities of the General Safety Advisory Committee provide the mainspring controlling the effectiveness of the entire safety program. This committee is appointed by the mayor to coordinate the efforts of all safety programs and to effect close liaison between supervisory and operating personnel. As presently constituted, it comprises twenty men, the chairmen of group or divisional safety committees plus members at large. Meeting once every other month, it acts as a board of review on all accident reports and

safety measures, and, through divisional or group committees, carries out investigations on all matters pertaining to safety. The general committee chairman is the personnel director of the Civil Service Commission, and its secretary is the safety and claims examiner.

From time to time subcommittees are appointed to study special problems affecting one or more groups of city employees. When their recommendations are approved by the general committee, a report is made to the mayor or, in some instances, to the director of the department involved. Prompt action usually results.

Divisional Safety Committees

Each city division now has one or more active safety committees, usually composed of nonsupervisory employees. Every accident occurring in the division or subdivision covered by a safety committee is immediately investigated by it to determine what caused the accident and what can be done to prevent similar mishaps.

In addition, these committees receive safety suggestions and complaints from employees, make area inspections, and report suggested improvements in methods and work practice to divisional management. This arrangement, at the employee level, is most effective in assuring the success of the program.

Role of Water Division

In the operation and application of the Akron safety program, the water division has played an important and integral part. Full cooperation is given, and its employees take a prominent place in all committee activities. Supervisors are awake to the possibilities and stimulate old and new employees alike to learn improved methods for their own protection. Over a 10-year period an encouraging downward trend in lost-time accidents has resulted.

Conclusion

The success of numerous industries in reducing injuries proves that the application of known preventive methods, by city personnel and management working together, would reduce the public employee accident toll to a gratifying degree. The immediate need is to obtain greater knowledge of the types of accidents and to disseminate more widely the existing information on cause and control. The activities now being undertaken by increasingly numerous cities with the assistance of the National Safety Council will fill that need. In the best democratic tradition, this work requires fine voluntary cooperation between the public employee and his employer, the political subdivision.

The good workman considers not only proper tools, necessary equipment, and selected materials but also a safe plan of execution. Safety-mindedness is a product of self-discipline, good instruction, proper direction, and continuous example.

When, through the prestige of a number of key cities, an authoritative approach to the safety problem has been established, the most valuable result will be the building up of safety consciousness among the ranks of public employees. Safety is a personal problem, to which each individual must devote thought and effort. A safe business, a safe employer, a safe employee—these are not accidents.

APPENDIX

Statement on Safety Policy and Procedure

On Aug. 25, 1952, an official safety policy for Akron was set forth in a written statement by Charles E. Slusser, Mayor-Mgr. The statement follows:

The city of Akron believes that safe working conditions for every one of its employees can be attained through use of safety equipment, by proper job instruction, frequent review of safe practices, and adequate supervision. This procedure defines Akron's policy with reference to safe practices and establishes responsibilities for the administration and coordination of an effective safety program as outlined:

1. Responsibilities

A. City of Akron responsibility. The city of Akron recognizes the need for the development of safe working practices for every job. It promotes the advancement of safety in design of buildings and structures, equipment, tools, and other work devices.

B. Departmental and divisional responsibility. Each department and division shall have a safety plan by means of which safe working practices which are in effect will be brought to the attention of every employee.

C. Supervisory responsibility. All supervisors will consider it an important and essential part of their job to administer the safety program.

D. Employee responsibility. All employees are required as a condition of their employment to follow all established safety practices.

E. Safety and Claims Division responsibility of the Civil Service Department. Responsibility for the promotion and coordination of the safety plan generally throughout the city departments lies with the Safety and Claims Division.

2. Departmental and Divisional Responsibility

Although detailed practices will depend on the safety requirements of the departments, the general pattern of the plan shall be as follows:

A. Safety information. Through the established lines of departmental organization, safety information shall be given to employees. Division heads shall arrange for regularly scheduled safety meetings with all their supervisors. The supervisors shall transmit safety information to their employees either through group meetings or by discussion with individual employees. Written safety rules shall be developed and formulated for safe working practices. These rules must be kept up to date, and must be thoroughly explained and made available to every employee.

B. Safety suggestions. Such suggestions made by employees to their supervisors will be referred through the line organization to the department heads. Prompt and definite replies shall be made to all suggestions.

C. Hazardous working conditions. All such conditions reported shall be studied and corrected either through the elimination of the hazard or by proper instruction and adequate supervision.

D. Occupational requirements. The ability to perform work assignments safely shall be a prime factor in the selection and promotion of employees.

E. Departmental safety representative. A representative for each division shall be selected to act as the coordinator of the safety plan within the division and as a medium of contact with the Safety and Claims Division. The duties of the representative shall not conflict with the responsibilities of supervisors for the safety of their employees.

F. Safety performance. Divisions shall submit data periodically to the Safety Division, in a form which will facilitate comparison with past performance.

3. Supervisory Responsibility

A. Success of program. The success of the safety program will depend to a great extent on the efforts of those who administer it, particularly first-line supervisors.

B. Correcting unsafe conditions. All supervision shall be constantly on the alert to observe unsafe working practices or conditions with the aim of immediate correction. If immediate correction is not possible, the situation should be reported to the next higher level of supervision.

C. Safety education of employees. The supervisor shall be sure that employees are well acquainted with existing safety rules and see that the rules are enforced: [1] Problems relating to safety on the job shall be discussed by supervisors either in group meetings or individually. [2] Supervisors shall encourage employees to submit safety suggestions and see that replies are made promptly. [3] Safety training of new employees shall be directed or conducted by supervisors, Safety and Claims Division to assist.

4. Employee Responsibility

A. Condition of employment. All employees shall be required "as a condition of their employment" to follow all safety practices which are established for the protection of themselves, their fellow employees, and the public.

B. Employee cooperation. The city of Akron expects that each employee will accept safety as a personal matter and cooperate in the safety program by developing safe work habits and by reporting hazardous working conditions.

5. Safety and Claims Division Responsibility

A. General functions. This division will assist in the development of departmental and divisional safety programs and will coordinate interdepartmental safety practices and will assist with safety engineering problems and keep the other departments informed of the safety performance within the city government.

B. Investigation of unsafe practices. This division is authorized to investigate practices or conditions which have caused, or may cause, accidental injury or property damage and make recommendation for their correction.

C. Outside Relations. The city of Akron's relations with outside industrial safety organizations or associations shall, in general, be carried on through the Safety and Claims Division. Public contact on industrial safety matters, however, may frequently involve the activity of other departments and divisions, and, under such conditions, the Safety and Claims Division will function jointly, by mutual agreement, with the department or division concerned.

Public Utilities Commission Activities in California

By Frank F. Watters

A paper presented on Apr. 24, 1953, at the California Section Regional Meeting, Palm Springs, Calif., by Frank F. Watters, Hydr. Engr., California Public Utilities Commission, San Francisco, Calif.

ALTHOUGH this paper is concerned with the California Public Utilities Commission and its regulation of approximately 456 privately owned public utilities, it is believed that the subject matter covered is broad enough in scope to be of considerable interest to the management of all types of water supply operations in that state and elsewhere. It should be noted that district, county, municipal, and mutual water utilities are outside the jurisdiction of this commission. Although the legal and financial arrangements under which the several types function may vary greatly, sound economic principles must be followed by all, to attain the common objective of providing the best possible service at the least practicable cost.

The present commission was established by constitutional amendment in 1911, and additional powers—including the regulation of water companies—were conferred upon it by legislation that became effective the following year. A supplementary statute, the Act for Regulation of Water Companies, went into effect in 1913. Other acts have since broadened and clarified the commission's authority. The various regulatory statutes were codified, without substantive change, as part of the Public Utilities Code in 1951.

The commission is both a court of record and an administrative tribunal exercising judicial and legislative powers. No state court may review its decisions except the supreme court, and then only to the limited extent provided by the Public Utilities Code. The legislative functions of the commission relate to rate, service, safety, finance, accounting, and certificate matters and constitute the bulk of its work. The determination of just compensation for properties sought through condemnation, reparation, and contempt proceedings are among its judicial functions.

Now under commission regulation are more than 1,500 privately owned utilities and transportation companies. These include gas, electric, water, telephone, and telegraph utilities; railroads, buses, trucks, airlines, and vessels transporting passengers or freight in intrastate commerce; and warehousemen, wharfingers, pipeline companies, carriers of household goods, and others.

The commission itself consists of five members appointed by the governor with the consent of the senate, serving biennially staggered 6-year terms. One of its members acts as president. The staff of the commission is organized into six divisions: administration,

legal, finance and accounts, utilities, transportation, and examiners. Although the principal office of the commission is located in San Francisco, a director is maintained in Southern California, where five of the six divisions also have representatives.

Regulatory Policies

With more than 40 years of experience in the regulation of various utility and transportation operations, the commission and its staff have naturally developed definite policies and procedures. Many of these have been dictated and influenced by decisions of the courts, while others have been established in cooperation with the management and consumer interests of the utilities regulated. Through liaison with commissions of sister states, still other concepts and practices have entered the regulatory process.

It should not be inferred that, to know the commission's present policies, all one has to do is to summarize its past decisions. True, certain cardinal principles will invariably apply, but the commission's day to day decisions are not governed by a rigid body of policies. Each case is decided on its own merits, and a long established policy may be discarded in the light of changing conditions. Additional sources of new policy concepts are staff presentations and the views of the utilities and other parties to proceedings. These help to prevent the commission organization from becoming stagnant.

Regulatory Proceedings

The regulatory work of the commission falls into two categories, formal and informal. The latter procedure permits assistance or relief to be given to the customers of the regulated utilities at staff level through an amicable adjustment with the parties concerned. Matters so disposed of may relate to improper billing, unsatisfactory service, incorrect metering, improper construction, and similar difficulties. Many complaints and misunderstandings have thus been handled through the years without the necessity of resorting to the more exacting and time-consuming formal procedure.

The items mentioned above may also be the subject of formal proceedings. In addition, state law requires formal commission action on certificates, extensions, rates, transfers, abandonments, agreements, and securities, to list the more common examples. In general, a formal filing may be made on any matter within the commission's jurisdiction but must state clearly the authorization or relief sought. Requests thus made by the regulated utilities are called "applications," while complaints made against these utilities, as well as commission investigations, are called "cases."

The most complicated and time-consuming of the formal proceedings are those involving rates. By far the greater part of the commission's time during the past few years has been directly or indirectly engaged in the processing of rate increase applications. This is not the fault of the utilities but is a direct result of inflation. Such proceedings normally require a public hearing and are participated in by many consumer interests.

Rate Application

The very document filed requires considerable time for the utility to prepare. In addition to the general requirements for any application, it must contain the latest available balance sheet and income and profit and loss statement, the present rate schedules

involved, the proposed increases, a description of the utility's property and equipment, and a statement of its original cost.

Effective Jan. 1, 1953, these rules were amended to require the following additional information: a statement of the depreciation reserve applicable to the original-cost statement and a summary of earnings on a depreciated rate base for the test period upon which the justification for the increase is predicated. If adjusted or estimated earnings summaries are included for successive periods, each must reflect the same present-day conditions, together with the recorded results from which developed. Factors commonly reflected in this way in such summaries are wage levels, income tax rates, purchased-water and electric-energy costs, climatic conditions, and representative system operations. When a utility has more than one district or separate service area, earnings results are required for the total utility operations of the company, as well as for the district for which rate increases are sought. Finally, the date on which the utility's exhibits will be ready and the date on which it will be prepared to proceed with its showing must be given.

The staff programs its work on the application in the order in which it was filed, consistent with the work load. The smaller water company rate proceedings are scheduled entirely within the hydraulic section, while those of the major companies are scheduled by the utilities division to fit the work load of its hydraulic, valuation, and research sections, as well as that of the utilities finance and accounts division. With the present large volume of rate proceedings, it currently takes roughly 6 months from the time of filing to completion of the proceeding for the average water utility, and, for very large companies, sometimes longer.

Staff Report

The staff exhibit is very comprehensive, as it becomes the basis for the staff's evidence during the public hearing. It usually takes the form of a single, bound report which includes, in chapter form, an introduction, brief history, description of system, balance sheet, income statement, operating revenues, operating expenses other than taxes and depreciation, taxes, fixed capital, depreciation reserve and expense, rate base, summary of earnings, service, rates, and summary and recommendations. Additional exhibits may also be necessary to cover a particular utility's affiliated interests and its special service and rate problems.

These studies require from 20 to several hundred man-days of engineering time, depending upon circumstances and the size and complexity of the utility operation. The average small company requires roughly 40 man-days. This time is exclusive of that of the accountants and other staff experts.

In making such a study, the engineering staff requires the utility involved to furnish all factual data practicable in advance of its scheduled starting date. To assure that the staff's instructions are understood, a preliminary field trip is usually made during this preparation period. Analysis of the data furnished is followed up by one or more field inspections by the engineers, for verification and for obtaining additional data, making spot analyses of company books and vouchers, inspecting the physical system, and making a customer service survey. During the same period staff account-

ants usually audit and analyze the company's accounting records and procedures, and work with the engineers in their analysis of the book accounts. From this first-hand knowledge of the water company's operations, the staff exhibit is developed.

Certain fundamental practices are followed in the staff exhibit. For example, the straight-line remaining-life method of depreciation is used, or sometimes a variation of it, the sinking-fund remaining-life method. This is done because the staff believes that the remaining-life method provides an equitable plan of charges to operating-expense accounts that attains the basic depreciation objective of recovering the original cost of fixed capital (less estimated net salvage) over the useful life of the property. The remaining-life principle, consistently applied over a period of years in connection with a depreciated rate base, will normally tend to produce equitable results in rate proceedings even though the plant accounting records have not been properly maintained (*1*).

Abnormal and nonrecurring expenses, income tax expense allowances for unincorporated utilities, working-cash allowances, donated capital, capital advanced by customers, and budgeted plant expenditures for the immediate future are all accorded a somewhat standardized treatment found to be fair to utility and customer alike.

The development of the rate base is another important consideration. This commission has long used the original- or historical-cost basis of determining fixed capital. Original cost is defined as the cost of the property, including land and rights of way, at the time the plant was first devoted to public service. Consequently, California has been referred to among regulatory bodies as "an original-cost state." A depreciated original-cost rate base is employed in relating the net revenue to a percentage return.

Public Hearings

Practically all rate proceedings are scheduled for a public hearing, presided over by a commissioner or a duly appointed examiner. In the conduct of such hearings, technical rules of evidence need not be applied and no informality in the hearing or manner of taking evidence invalidates a decision approved by the commission. The hearings follow generally recognized court procedures, however, and are conducted under the commission's rules of procedure.

At the hearing, the utility seeking the rate increase proceeds to offer sworn testimony, through its officials and expert witnesses, generally similar in practice to that described for staff presentations. In addition, the utility may offer such other testimony as it deems pertinent in support of positions it has taken which are known to be different from commission practice. Cross examination of these company witnesses may be conducted by the public or its representatives, the staff representatives, and the presiding officer.

The same general procedure is followed by other parties to the proceeding who care to testify, and by the staff. Usually the testimony of the other parties covers only that portion of the proceeding which affects their interests directly. The staff's position in these proceedings is predicated simply upon the concept of reasonable costs for reasonable service. It is intended to favor neither the utility nor the customer but only to follow the requirements of the law.

In the interests of the public, attorneys are assigned to act as legal repre-

sentatives of the staff in all of the more important proceedings—chiefly those involving rates—before the commission. The staff counsel is charged with the presentation of staff evidence and cross examination of witnesses, and, whenever appropriate, submits motions, offers argument, and files briefs. An attorney once assigned as staff counsel in a particular proceeding is disqualified from advising the commission in that proceeding.

Commission Decision

Following submission of the proceeding, the entire public record must be carefully reviewed and a suggested decision prepared by the examiner for commission consideration. Upon determination of the proper revenue to be allowed, rates must be designed by the engineering staff to yield the amount sought without discrimination in schedules and between classes of service. After serious review by the assigned commissioner, during which many revisions may be made, the decision is passed upon by the commission. Once the new rates are established, the law prohibits variation from them.

Expedition of Proceedings

In rate proceedings involving large water companies, several days of hearing over a period of some months may be necessary for all parties to be heard and cross examined. Even the small utility hearing may have to be put over to a later date if it is not carefully planned in advance. In such proceedings, it is the burden of the applicant utility to prove by clear and convincing evidence that the increase is justified. Interested parties must be allowed reasonable time to study exhibits and testimony and to prepare their own presentations.

One means of assuring a shorter hearing period is for the company to submit copies of its exhibits to the several parties and the staff approximately 30 days in advance of the initial hearing. For very small companies, this time may be reduced to 2 weeks. In following this general procedure, however, arrangements should first be made with the hearing officer. The staff, without necessarily obligating itself, will make every effort to reciprocate by releasing its exhibits a few days prior to the hearing. The reason it cannot release them earlier is that the hearing date usually follows closely upon the staff's scheduled completion date.

For the very large utilities—although it is not restricted to them—a prehearing conference held by the presiding officer may be advantageous in expediting orderly conduct and disposition of a proceeding. Through this procedure, issues may be simplified or formulated, arrangements made for the exchange of proposed exhibits or testimony, and the number of witnesses limited by agreement of all parties of interest. In this and other ways (*2*) the so-called regulatory lag may be reduced.

To those utility representatives who ask, it is suggested that company exhibits be similar in form to those used by the staff. This is recommended because data summarized by tables and charts are explained adjacent thereto in the text of the report rather than by a series of separate exhibits of data and amplifying testimony. When testimony is being given, both written text and figures need only be highlighted for intelligent presentation. Important relationships and conclusions should, of course, be emphasized.

One of the best means of shortening a proceeding is for the utility to maintain

accurate, up-to-date books and records. Particularly in the smaller water companies, much unnecessary time is required of the staff experts in redeveloping and adjusting poorly kept accounting and statistical records.

Future Outlook

Many regulatory problems are yet to be satisfactorily solved. Others already worked out need reexamination in the light of today's changed conditions. Some of the more important ones which the staff hopes to rework or have formulated in the next few years will be of interest.

The staff feels that it would be beneficial to have approved standards for water service. The National Association of Railroad and Utilities Commissioners is in the process of drafting a set of standards. Using these and the standards adopted by the AWWA California Section (*3*) as a starting point, it may be possible, through cooperation with the water utilities under commission jurisdiction and their customers, to develop satisfactory commission standards for California reasonably soon. This objective should be accomplished through statewide public hearings, so that the best interests of all concerned can be served.

The staff is quite frank to admit that the uniform system of accounts prescribed for California water companies is long overdue for revision. Many of its practices are antiquated, others ambiguous or wholly inadequate. Recently the commission authorized the staff to initiate proceedings looking to the adoption of a revised system of accounts by the beginning of 1954. It is expected that the formal proceeding on this matter will be announced very soon. In this sphere also, the commission hopes to work with the water utilities to establish a modern and fully applicable account system.

Then there is the familiar question of who pays for public fire protection—the customer through his water rates or the fire protection agency through taxation. Apparently additional clarification of this issue is now needed and would probably be best obtained through public hearings.

For companies serving fast growing areas, the subdivision main extension rule appears to be causing considerable difficulty in financing. Never conceived for today's rapidly built-up, large-scale subdivision developments, it, too, is due for review.

Notwithstanding what may seem to be shortcomings, the commission and its staff stand ready and able to help the privately owned public water utility in meeting its regulatory problems.

References

1. Determination of Straight-Line Remaining-Life Depreciation Accruals—Standard Practice U–4. Utilities Div., Calif. Pub. Utilities Com., San Francisco (Jan. 30, 1953).
2. HULS, H. P. Regulatory Lag in Public Utility Rate Making. *Pub. Utilities Fortnightly*, **50**:650 (1952).
3. Standards of Minimum Requirements for Safe Practice in the Production and Delivery of Water for Domestic Use. *Jour. AWWA*, **41**:3 (Jan. 1949).

Purification Plant Waste Disposal

Committee Report

A committee report presented on May 11, 1953, at the Annual Conference, Grand Rapids, Mich., by William W. Aultman, Chairman, Committee E5.8—Disposal of Wastes From Water Purification and Softening Plants; Asst. Director, Dept. of Water and Sewers, Miami, Fla. Other members of the committee were: A. P. Black, J. B. Dean, P. D. Haney, J. J. McCarthy, K. E. Shull, F. S. Taylor, and C. F. Wertz.

Committee Statement

THE assignment of Committee E5.8 (Disposal of Wastes From Water Purification and Softening Plants) has been divided for study and report purposes into three specific phases—the disposal of wastes from: [1] filter plants and coagulation basins; [2] ion-exchange softening plants; and [3] lime and lime–soda ash softening plants.

The committee was appointed in 1946, and at the 1947 AWWA Conference a preliminary report was made on all three phases of the study. At the 1949 AWWA Conference, final reports on the disposal of wastes from ion-exchange and lime softening plants were given. The final report on the disposal of wastes from filter plants and coagulation basins was delayed until the 1953 AWWA Conference because of the illness or work load of some of the committee members handling that phase of the study.

The final committee report should be considered as consisting of the following separate published reports:

1. "Lime and Lime-Soda Sludge Disposal," by William W. Aultman (December 1947 JOURNAL, page 1211)
2. "Brine Disposal From Sodium Zeolite Softeners," by Paul D. Haney (December 1947 JOURNAL, page 1215)
3. "Disposal of Wash Water From Purification Plants," by Harry R. Hall (December 1947 JOURNAL, page 1219)
4. "Lime and Lime-Soda Sludge Disposal," by A. P. Black (September 1949 JOURNAL, page 819)
5. "Brine Disposal From Cation-Exchange Softeners," by Paul D. Haney (September 1949 JOURNAL, page 829)
6. "Disposal of Wastes From Filter Plants and Coagulation Basins," by John B. Dean (this issue, page 1226).

It was realized that each treatment plant has a problem that is probably unique to itself. Therefore, the desire of the members of this committee has been to present a report containing a general coverage of the subject, with sufficient references to guide anyone endeavoring to solve a specific problem to information applicable to that problem.

One phase of treatment plant waste disposal has not been covered—that of wastes containing radioactive sub-

stances. This subject was purposely not included, as it is a matter for specialized study and is being investigated by other groups.

The reports given in 1947 and 1949 have been reviewed and are considered sufficiently complete to be accepted as the final report on the phases covered therein. With the report on the one remaining phase of the investigation being published herewith, the committee asks that the entire series of reports be accepted as final and that the committee be discharged.

Disposal of Wastes From Filter Plants and Coagulation Basins—*John B. Dean*

A report presented by John B. Dean, Div. Engr., Supply and Purifying Section, Water Div., St. Louis, Mo.

At present very few water purification plants are actually prohibited from discharging filter washings and sludge from basins into streams or lakes, but there is a definite trend toward enactment of federal and state laws to prevent the pollution of these waters. In the future the disposal of such wastes is likely to be a matter of increasing concern to designers and operators of water purification plants.

Character of Wastes

Wastes from water purification plants are composed principally of the suspended matter in the raw water plus any added inert matter and precipitated material resulting from the reactions between the chemicals applied and the dissolved substances in the water. The nature of the wastes removed in the various stages of treatment is approximately as follows:

1. From grit chambers: sand.
2. From plain settling or sedimentation basins: sand and suspended clayey matter that will settle out in a relatively short time without the use of coagulants.
3. From coagulation and sedimentation basins: (a) most of the suspended matter remaining in the water after plain sedimentation; (b) calcium carbonate and magnesium hydroxide resulting from the addition of lime for partial softening or for conditioning prior to coagulation; (c) hydroxides of iron and aluminum, if iron and aluminum compounds are used as coagulants or if iron compounds are present in the raw water; (d) carbon or adsorptive clay, if these materials are applied in basins; (e) plankton; and (f) organic matter.
4. From filters: (a) very fine clayey particles remaining in the water after sedimentation; (b) hydroxides of iron and aluminum; (c) iron oxide, when iron removal is effected by aeration prior to filtration; (d) activated carbon, when this material is applied; (e) plankton and algae, when these are present in the water; and (f) organic matter.

Weight and Volume of Wastes

The amount of sludge, by weight, that will result in each stage of the purification process can be estimated approximately from the characteristics of the raw water and the treatment applied.

Grit chambers for the removal of the coarser suspended matter are not

commonly used at present, as presedimentation basins affording longer detention periods are employed for this purpose. It may be of interest to note that a grit chamber the bottom of which consisted of six hoppers, each provided with a discharge valve, was in use at the Chain of Rocks Plant at St. Louis, Mo., from 1916 to 1936, when a change was made to a presedimentation basin. With a detention period of only 6½ min, an average of 12.8 per cent of the suspended matter in the raw water was removed. The grit chamber was cleaned by flushing and the use of fire streams. The grit chamber was beneficial in reducing the size of the sand banks that accumulated in the basin into which the raw water was delivered.

By using presedimentation basins affording a detention period of approximately 3 hr, the removal of 30–60 per cent of the suspended matter has been accomplished without chemicals. The use of a mechanism for the continuous removal of sludge from presedimentation basins is desirable in order to prevent it from accumulating and reducing the effective volume and detention time.

Nearly all of the suspended matter remaining in the water after presedimentation will be deposited in the coagulation and sedimentation basins, together with the precipitated material resulting from the reactions between the chemicals applied and the dissolved matter in the water. In estimating the weight, it is necessary to take into account the fact that the results of the treatment usually fall considerably short of the figure that the theoretical chemical reactions indicate.

The amount of suspended matter removed by the filters can be calculated from the reduction in turbidity, assuming the coefficient of fineness to be 1.00. The turbidity of the water applied to the filters is not likely to exceed 30 ppm and may be less than 1 ppm.

At St. Louis, Mo., where Missouri River water is treated and the sludge is pumped daily from the presedimentation and coagulation basins and transferred through sewers and open ditches to impounding areas, the solids content is usually approximately 20 per cent by weight. At times when the river turbidity is low and very little sand is being discharged into the basins, the solids content may be as little as 10 per cent. When sludge is permitted to accumulate in basins for several months, the lower part becomes consolidated to such an extent that it will not flow. When this sludge is transferred to the river by the use of fire streams, tractors, and flushing water, it is diluted only enough to flow through large, straight sewers, but, if it were to be pumped or conducted through open ditches to places of disposal, dilution to a solids content of 20 per cent would probably be desirable.

Assuming that the solids content is 20 per cent, the amount of liquid sludge to be handled could be estimated by determining the volume resulting from the addition of 4 lb of water to each pound of dry sludge. At this degree of dilution, the amount of liquid sludge would be approximately 0.5 gal, or 0.07 cu ft, per pound of sludge on the dry basis. If the solids content is 10 per cent, the volume of wet sludge would be approximately twice as much. Anyone designing a sludge-handling system would give consideration to the nature of the

sludge when estimating the volume to be handled and would select the sizes of pumps and pipe accordingly. Frequently sludge pumps are operated only on the day shift, for the length of time required to lower the sludge line in the basins to the desired elevation. If this practice is to be followed, pumps and pipe of correspondingly larger sizes will be necessary.

If basins are cleaned after being in service for several months and the sludge is transferred into pools in one operation, the space required will be the volume of the sludge after dilution to a consistency that would permit it to flow through the sewers or ditches. If the sludge is transferred daily from the basins to pools, it will lose moisture gradually, with a resultant increase in the average percentage of solids, and the same volume of storage will contain more sludge on the dry basis than if it is filled in one operation.

TABLE 1

Arrangement of Purification Plants

Arrangement	Plants Reporting	
	No.	*per cent*
Filters alone	318	16.52
Coagulation basins and filters	71	3.69
Coagulation and sedimentation basins and filters	1,416	73.56
Presedimentation, coagulation and sedimentation basins and filters	111	5.77
Plain sedimentation basins and filters	3	0.16
Coagulation and sedimentation basins without filters	2	0.10
Plain sedimentation basins alone	4	0.20
Total	1,925	100.00

At Howard Bend Plant, St. Louis, samples of ground fill made with sludge were accurately measured in place at three widely separated points and completely dried and weighed. It was found that 1 cu ft of fill contained an average of 76 lb of dry sludge. Where the sludge is similar to that at the Howard Bend Plant, this unit weight could be used for estimating the number of acre-feet of space required per year for the final disposal of the sludge produced.

The average solids content of the filter washings can be estimated from the turbidity removed by the filters and the amount of wash water used. As an example, assume that the turbidity removed is 5 ppm and that the wash water is 1 per cent of the amount filtered. For every million gallons filtered, 41.6 lb of suspended matter would be removed and 10,000 gal, or 83,300 lb, of water would be required to remove it. Thus, the average amount of solids in the filter washings would be 0.05 per cent, or 500 ppm.

TABLE 2

Methods of Removing Sludge From Basins

Method	Plants Reporting	
	No.	*per cent*
Flushing and use of fire streams	1,294	90.55
Flushing and use of bulldozers	7	0.49
Draglines	2	0.14
Mechanism for continuous removal	124	8.68
Manual	2	0.14
Total	1,427	100.00

Questionnaire Returns

In order to obtain information on current methods and control measures for disposing of wastes from water purification plants other than

those used primarily for softening, questionnaires were sent to the sanitary engineers of all the states and territories. The territories of Alaska and Hawaii and the state of North Dakota reported that the questionnaire did not apply to any of their plants. Questionnaires were sent to the individual plant operators in two states, upon the recommendation of the state sanitary engineers. Three states failed to reply. The replies received represent 1,925 plants. The data obtained have been tabulated under various headings.

Arrangement of Plants

Table 1 shows the number of plants operating with various arrangements of basins and filters. The questionnaires indicated that the 318 filter plants being operated without conditioning basins are mostly slow sand filters and filters for removal of iron precipitated by aeration. The layer of sand and sediment removed from the surface in cleaning slow sand filters normally would not be dumped into a stream or lake. Apparently disposal of the washings from the iron removal filters does not present any serious problem, as it is reported that they are frequently discharged into sewers, watercourses, and roadside drains.

Sludge Removal and Disposal

The number of plants using the various methods of sludge removal is given in Table 2. Several replies to the question on mechanisms for continuous removal of sludge mentioned that solids-contact plants were included. Several stated that the sludge is drawn from basins at intervals by partially opening valves at the sludge outlets. This method is commonly practiced but results in the removal of only a small part of the liquid sludge near the outlet. Usually it is necessary to take the basins out of service and clean them by other means in order to remove the majority of the sludge. Dredging was at one time used to remove sludge from sedimentation basins at St. Louis and is one of the methods sometimes employed for removing sediment from impounding reservoirs.

Table 3 shows the number of plants disposing of basin sludge by various methods. Approximately 92.5 per cent of the plants discharge basin sludge directly into streams or lakes; and approximately 3.5 per cent, into storm sewers or surface drains. Thus, the sludge from 96 per cent of the plants is eventually discharged into streams or lakes without treatment. In one plant where sludge is discharged into sanitary sewers, it is bypassed around the sewage disposal plant while the basins are being cleaned.

TABLE 3

Disposal of Basin Sludge

Discharged Into	Plants Reporting	
	No.	*per cent*
Streams or lakes	1,414	92.42
Storm sewers or surface drains	53	3.46
Sanitary sewers	4	0.26
City reservoirs	2	0.13
Irrigation ditches	1	0.07
Dry creeks	3	0.20
Sludge beds or low ground	47	3.07
Impounding basins (discharged into rivers at high stages)	6	0.39
Total	1,530	100.00

The replies indicate that the sludge is usually not removed from sludge beds. In one plant, the dry sludge is hauled away, and, in another, it is

pushed up on the earth dam of the impounding reservoir by a bulldozer. In still another plant, the sludge is removed from a pond in the form of a ditch and deposited on the banks by the use of a dragline. After the sludge has dried it is hauled away. Where sludge is impounded and discharged into streams at high stages, it is flushed out of the basins (two plants), or flows out by gravity when sluice gates are opened (four plants).

The use of vacuum filters for dewatering basin sludge has been proposed. One item in the questionnaire asked about experimental work done in water plants with vacuum or pressure filters for this purpose. None of the respondents knew of any such experiments. Vacuum filters have been used successfully in industry and for the removal of solids from sewage, and may be of value where the discharge of sludge into a stream or lake is prohibited and there is insufficient room for impounding it, or where the suspended matter in the sludge will not settle out readily.

Kenneth E. Shull, Supt. of Purification, Philadelphia Suburban Water Co., is investigating the use of vacuum filtration for dewatering sludge and has done a considerable amount of work to determine the optimum pH value and the best chemical treatment to apply to the sludge at the Crum Creek Plant, Bryn Mawr, Pa., in order to form the filter cake in the shortest time.

Use of Sludge

One respondent stated that there was very little demand for sludge and all others reported that there was none. The popular belief is that basin sludge would be a valuable fertilizer. Actually, it is no more fertile than river bottom soil and its physical characteristics are very similar to those of gumbo.

Sludge from coagulation basins is sometimes returned to the raw water to improve sedimentation in the presedimentation basins. This practice was tried at the Howard Bend Plant but was discontinued because it did not result in any noticeable reduction in the amount of chemicals used and necessitated rehandling some of the sludge.

A method of recovering alum coagulant from basin sludge by treatment with flue gas containing sulfur dioxide has recently been developed, according to Fred Eidsness, Consultant, Black Labs., Gainesville, Fla.

Disposal of Filter Washings

The number of plants reported to be disposing of filter washings by various methods is shown in Table 4. Approximately 82.5 per cent of the plants discharge filter washings directly into streams or lakes; and approximately 10.5 per cent, into storm sewers or surface drains. Thus, the washings from 93 per cent of the plants eventually are discharged into streams or lakes without treatment. In most plants, the filter washings are disposed of in the same manner as the basin sludge.

As previously mentioned, filter washings are likely to have a turbidity of not more than 500 ppm, and there would usually be no objection to discharging them into streams or lakes. If this practice does prove objectionable, however, on account of turbidity, iron oxide, suspended carbon, or other factors, the washings could be combined with the incoming raw water or impounded, the clear supernatant water being returned to the system or drained off into watercourses. The amount of sediment deposited would be so little

that cleaning the impounding basin would not be required frequently.

Of 1,601 plants reported on, 516, or 32 per cent, chlorinate prior to filtration. This practice should be beneficial in reducing the number of bacteria in the filter washings.

Of thirteen replies to the question on the presence of obnoxious odors resulting from impounding filter washings, all stated that there were no complaints on this matter. In nearly all of these plants, the filter washings and basin sludge were impounded together, so that the answers would apply to both. At St. Louis, where the sludge is impounded separately, no obnoxious odors arise from the sludge beds.

Handling of Sludge Fills and Beds

Most of the information on which the following statements are based was obtained by the author from experience with filling low ground and borrow pits with basin sludge at the Howard Bend Plant.

If wet sludge is to be conveyed to sludge beds through a sewer, which is likely to be laid on a slight gradient, the upper end of the sewer should, if possible, be arranged to operate under a small head. If sludge is to be conveyed through open ditches, they should be as straight as possible and narrow and deep rather than wide and shallow. At St. Louis, ditches having a slope of 3 in. per 100 ft have been found satisfactory for transferring sludge. Fills made with sludge after being completely dried out were found to have a slope of approximately 4 in. per 100 ft of distance from the point at which sludge was discharged into the bed. Usually the areas to be filled are surrounded by levees. If there are borrow pits or depressions in the leveed area some distance from the point where the sludge is to be discharged, it will often be advantageous to continue the sludge ditch across the leveed area to the pits in order to fill them with the heavy sludge. During periods of freezing weather the sludge has a tendency to build up in the pool near the point where it is discharged from the sludge ditch, finally blocking off the discharge end of the ditch and causing it to become filled with solidified sludge. At such times it will be advantageous, if possible, to discharge the sludge into a stream or sludge pool where there is a free outfall from the sludge ditch or sewer.

TABLE 4

Disposal of Filter Washings

Place or Method of Disposal	Plants Reporting	
	No.	*per cent*
To stream or lake	1,404	82.64
To storm sewers or surface drains	181	10.65
To sanitary sewers	42	2.48
To lagoons from which solids are not removed	32	1.88
Impounded and discharged to streams at high stages	4	0.24
Recycled through plants	6	0.36
To city reservoirs	2	0.12
To irrigation canal	1	0.06
To roadside ditches	5	0.284
To drainage ditches	5	0.284
To low ground	2	0.12
To dry creeks	13	0.77
To beds from which sludge is removed	2	0.12
Total	1,699	100.00

Where a fill of several feet is to be made with sludge, a more consolidated fill will result if the sludge is applied at intervals and each layer is allowed

to dry before the next layer is applied, instead of continuously discharging sludge into one pool. Therefore, if practicable, the area to be filled should be divided into several sections or ponds so that the sludge in some can be drying while others are being filled with liquid sludge. As the solids in the sludge will be only approximately 20 per cent of the volume, the levees surrounding the ponds should be built to an elevation approximately 3 ft higher than the final surface of the fill, so that the depth of liquid sludge will be great enough to deposit an appreciable layer of fill at each application. The sludge is ordinarily discharged into each pond at only one point, near which the heavier fractions tend to settle out and become less fluid. The supernatant water will collect on the opposite side and in the corners of the pond. If this water is removed by pumping or by means of drains through the levee while liquid sludge is being discharged into the pond, the sludge will flow into the areas which the water has vacated. When the application of sludge is discontinued for drying, it will be desirable to remove all supernatant water to get the most benefit from the available time for drying. As the sludge dries, cracks about as deep as the layer of deposit will form in all directions; the blocks of sludge surrounded by the cracks will become smaller and the cracks wider as the drying continues. The amount of drying or the time required for it will be affected by the humidity and temperature of the air, the wind, and the nature of the soil underlying the area being filled. Fills can be made by continuously applying sludge without drying, but precautions should be taken to avoid the passage of cranes or heavily loaded trucks over such fills for several years after they have been completed.

Where the use of sedimentation basins is necessary and the discharge of sludge into a stream or lake is prohibited, the disposal of sludge could be accomplished with sludge beds if enough land for spreading and drying and a means of transferring the sludge to the beds were available. The spreading could easily be done if the drains of the basins were at an elevation high enough to make possible the flow of sludge from the basins to the beds, or if the basins were equipped with a mechanism for the continuous removal of sludge. In the latter instance, the sludge is usually pumped to a height from which it can flow into the beds. In existing basins that are cleaned at intervals of several months and drained through sewers several feet below the surface of the ground, the transfer of sludge to beds would be a very difficult undertaking. Where the area of land available for depositing sludge is limited, the principal problem will be to dry the sludge so that it can be removed soon enough to provide space at all times to receive the sludge being discharged from the basins.

In one plant mentioned in a questionnaire reply, the sludge is impounded and later pushed out on the dam of the impounding reservoir by means of a bulldozer; the sludge must, therefore, have been dried sufficiently not to flow when handled. In another plant, the sludge is discharged into a pond in the form of a ditch and removed and deposited on the banks of the ditch to dry, by the use of a dragline; after drying, the sludge is hauled away. This suggests a method of disposing of sludge, without the use

of a large amount of land, by means of two or more sludge ponds, narrow enough for a crane standing on either bank to reach the center and long enough to provide the proper volume. The sludge could be discharged intermittently into the ponds and would be drying in some while fresh sludge was being discharged into the others. The supernatant water could be drawn off at the end opposite the one into which the sludge would be discharged. Once the pond had been filled and made to drain properly, the sludge would shortly become consolidated to such an extent that it could be removed with a clamshell or dragline bucket.

The following observations, made at St. Louis, have some bearing on the proposed method of disposing of sludge. During the summer of 1952 the earth for constructing the embankment of a road across an old sludge fill at Howard Bend Plant was obtained by excavating a borrow pit—approximately 25 ft wide, 6 ft deep, and 600 ft long—beside the embankment. Sludge from the clarifier basins was discharged into one end of the borrow pit from May 9 to June 9, when the pit had been completely filled and some sludge had flowed out at the other end. On July 31, a total of 51 days after discontinuing the discharge of sludge into the borrow pit, the sludge had dried to such an extent that it could be removed with a dragline and used to make shallow fills at the top of the embankment. This sludge could not have been handled with a bulldozer, but it was possible to transfer it by dragline or clamshell to the top of a levee to dry. In this instance, conditions were very favorable for drying the sludge. In making the borrow pit, all of the old sludge was removed, exposing the original sandy soil at the bottom of the pit. The weather was fair and warm. Under ordinary conditions, the sludge would probably have dried within 4 months to a condition suitable for handling with a clamshell and could have been loaded into dump trucks and hauled away.

Effect on Streams

When raw water for a purification plant is taken from a stream and the purification wastes are discharged back into it, as is frequently done, the amount of suspended matter returned is the same as that in the raw water plus any added inert material and the precipitated material resulting from the reactions between the chemicals applied and the dissolved substances in the raw water. If the purification wastes were continuously disseminated throughout the cross section of the stream, the concentration (in parts per million) of suspended solids in the river below the point of discharge would theoretically equal the original raw-water concentration times 100, divided by 100 minus the percentage of stream flow withdrawn for treatment, plus the added solids resulting from treatment (expressed in parts per million of the stream flow below the point of withdrawal). Obviously, if only a small percentage of the stream flow were withdrawn, the theoretical increase in turbidity would be insignificant.

Frequently, however, sludge is allowed to accumulate in basins for several months and is then discharged into streams in large amounts over short periods of time, with resultant high turbidity which may not be disseminated throughout the cross section of the stream for some distance. This

condition would naturally be objectionable to operators of plants obtaining raw water from the same stream below the point of sludge discharge, especially if located on the same side of the river. In some instances, mudbanks have formed below the points of purification waste discharge.

The results of discharging purification wastes into streams will be less objectionable if basins are cleaned only when the streams are at high stages. This cannot always be accomplished at plants located in river bottoms, because the basins are usually constructed partly in cut and partly in fill, with the result that the drains from them are appreciably lower than the river banks and the sludge cannot be made to flow through the sewers satisfactorily when the outfalls are submerged. In designing new plants, the bottom of the basins should, if possible, be so elevated that they can be cleaned at high river stages. The use of a mechanism for continuous removal of sludge would be another means of avoiding the discharge of large amounts of sludge into streams during short periods.

Water purification plants are frequently blamed for polluting streams, but actually the number of coliform bacteria returned with the sludge and filter washings is much lower than the number removed from the streams with the raw water. This was demonstrated at St. Louis by determining the number of bacteria associated with 1 mg of sludge and comparing it with the number of bacteria in the amount of raw water that would contain 1 mg of suspended solids. For this purpose, 1 ppm of suspended matter is assumed to be the same as 1 ppm of turbidity. The method of calculation can be demonstrated best by an example.

A sample of sludge obtained during the cleaning of basin No. 1 at the Chain of Rocks Plant on July 18, 1952, was found to contain 1,070 total bacteria and 3.14 *Esch. coli* per milligram of solids in the sludge. During the time that the sludge was being deposited, the average turbidity of the river water was 1,700 ppm (equal to 1,700 mg per liter), the total bacteria 14,300 per milliliter, and the *Esch. coli* 7,100 per 100 ml. Therefore, the volume of river water containing 1 mg of turbidity or solids was 0.588 ml, and the total number of bacteria in the water containing 1 mg of solids was $0.588 \times 14{,}300$, or 8,400. Similarly, the river water containing 1 mg of solids would contain 0.588×71, or 42 *Esch. coli.* Thus, it can be seen that the milligram of solids in the river water as turbidity was associated with 8,400 bacteria, of which 42 were *Esch. coli,* when it was removed from the river, and with only 1,070 total bacteria and 3.14 *Esch. coli* when it was returned to the river. Similar calculations were made for other basins, and the results are shown in Table 5.

The four basins at the Chain of Rocks plant from which the sludge samples were taken are operated in series. Basin No. 1 is a presedimentation basin from which the water flows through mixing and conditioning chambers into basin No. 2 and then through the other two. The basins are cleaned one to three times per year with fire streams, flushing water, and bulldozers. In each instance, the turbidity and bacterial content of the river water used in making the calculations were averages for the periods during which the sludge was being deposited.

At Howard Bend, basin No. 8 is one of four with conical bottoms, designed

for use with a clarifier mechanism not yet installed, but equipped with pumps for removing liquid sludge. The basin is used for presedimentation, liquid sludge being removed daily by pumping, and the heavier deposit about three times per year by fire streams. The sludge sample was taken during cleaning and was deposited from river water over a period of 4 months. Basin No. 3 is one of four similar to basin No. 8 but is equipped with a clarifier mechanism and used for coagulation. The sludge sample was taken at the pump discharge and was deposited from water withdrawn from the river on the same date. Basin No. 10 is used for sedimentation following coagulation and is cleaned once a year with tractors and flushing water. The sludge sample was taken during cleaning and was deposited from water withdrawn from the river over a period of approximately 1 year. The sample of filter washings was assumed to be deposited from water taken from the river the same day. The water is chlorinated prior to filtration.

This investigation shows that the average number of *Esch. coli* returned to the river with 1 mg of solids in the sludge is approximately 10 per cent of the number taken out with 1 mg of suspended solids in the river water.

State Regulation of Waste Disposal

In the questionnaire, the state sanitary engineers were asked if the discharge of basin sludge or filter washings into streams or lakes was considered a violation of their state water pollution laws or regulations. The replies showed that such discharge is not considered a violation in the following states:

Alabama	Montana
Colorado	Nebraska
Georgia	North Dakota
Idaho	Ohio
Illinois	Oregon
Kansas	Rhode Island
Louisiana	Utah
Maine	Vermont
Mississippi	Wisconsin
Missouri	

In the following states, the discharge of these wastes into streams or lakes was reported to be a violation:

Massachusetts	New Mexico
Nevada	Wyoming
New Jersey	

In the following states, the discharge of these wastes into streams or lakes was reported to be controlled as indicated:

Arizona. Each instance is considered on its own merits.

Arkansas. Such discharge is permitted if the dilution is sufficient. The requirement of use of lagoons where there would be insufficient dilution is being considered.

California. One of nine regional pollution control boards determines if the instance is a violation. Up to 1953 no water purification plants had been restricted.

Connecticut. Such discharge is permitted unless special conditions make treatment necessary. The method of treatment would be lagooning or transfer to points of greater dilution.

Delaware. Plans and reports are required from all parties causing new pollution. The pollution problem is being studied and different restrictions may apply in different areas.

Florida. There is a state law to control pollution of streams and lakes, but it has not been applied to water purification plants.

Indiana. The current regulations of the stream pollution control board do not

TABLE 5

Comparison of Bacterial Populations in Raw Water and Sludge

Basin No.	Date of Sample (1952)	Bacteria Associated With 1 mg Solids			
		Total		*Esch. coli*	
		Raw Water	Sludge	Raw Water	Sludge
Chain of Rocks Plant					
1	July 18	8,400	1,070	42	3.14
2	July 21	8,400	2,390	42	0.00
3	May 20	7,500	2,780	37	7.66
3	Sept. 18	13,000	2,760	66	0.07
4	Sept. 19	13,000	2,030	66	0.20
Howard Bend Plant					
8	Aug. 19	22,600	42,800	26	4.28
3	Aug. 19	39,400	68,400	41	11.60
10	Sept. 26	18,900	435	45	18.90
Filter washings	Aug. 21	30,000	735	60	0.00

prohibit discharge of water purification wastes into streams or lakes, but apparently this board has the power to adopt new regulations at any time.

Iowa. Such wastes may be discharged into streams or lakes if a nuisance is not created or other water uses are not interfered with.

Kentucky. No general ruling has been made on water purification wastes. Restrictions would apply only in specific instances.

Maryland. The question has not arisen.

Michigan. Such discharge has not been declared a violation of the Water Pollution Control Act. Determination of violation will depend on effects.

Minnesota. The water pollution control commission has not yet considered the problem of wastes from water purification plants, but the discharge of these wastes into streams and lakes is believed to be a violation of existing regulations.

New Hampshire. Rulings are governed by the classification of the stream involved.

New York. Apparently the state health department has control over pollution of lakes and streams but has not prohibited water purification plants from discharging wastes into them.

North Carolina. No reply.

Oklahoma. A permit is required to discharge basin sludge into streams or lakes. There is no restriction on discharge of filter washings.

Pennsylvania. The sanitary water board determines in every instance if the discharge of the wastes would be a violation of the water pollution laws.

South Carolina. No reply.

South Dakota. Regulation of disposal of water purification wastes is now under consideration.

Tennessee. Discharge of wastes into streams or lakes is a violation if it interferes with reasonable use of water.

Texas. State laws prohibit pollution of streams or public bodies of water, but water purification plants have not been restricted.

Virginia. No reply.

West Virginia. Discharge of basin sludge into certain streams would be a

violation. The discharge of filter washings is not considered a violation.

Washington. Discharge of water purification wastes into streams or lakes would be a violation if it caused excess turbidity or damaged fish life.

The replies indicate that, in nearly every state, the health department or a commission or board has the authority to prevent the pollution of streams or lakes. Apparently these regulatory bodies are concerned principally with the disposal of sewage and industrial wastes and have usually not restricted the water purification plants.

Conclusions

1. Water purification plants located on large rivers or lakes where reasonable dilution is possible will probably be permitted to discharge wastes into them indefinitely, and, if approved by the federal and state authorities, this method of disposal would be utilized as being the least expensive and most convenient.

2. In designing new plants, if practicable, the bottom of the basins and the drains from them should be at an elevation high enough to permit cleaning when the river stage is high, if the sludge is to be discharged into a river, or high enough for the sludge to flow into beds, if it is to be impounded.

3. The use of a mechanism for the continuous removal of sludge will result in a steady flow to the river or sludge beds and is a means of avoiding periodic cleaning of basins.

4. Where purification wastes are returned to the same stream from which the raw water is obtained, the number of coliform bacteria returned with the wastes is much less than the number in the raw water.

5. Filter washings contain such a small amount of suspended matter that their return to a stream would not usually be objectionable. If it is objectionable, the washings can be combined with the raw water entering the purification system.

6. Water purification wastes can be discharged into a lake or impounding reservoir belonging to a city or water company without restriction by health authorities if the outflow of the lake or reservoir is not affected.

7. When the discharge of water purification wastes into a stream or lake is prohibited, the wastes can be impounded and the clear supernatant water drawn off into watercourses or combined with the raw water. Unless there is space available for the perpetual accumulation of sludge, some means of removing it from the sludge beds will be necessary.

Algae Control in Small Water Plants

By D. H. Matheson

A paper presented on Apr. 8, 1953, at the Canadian Section Meeting, Buffalo, N.Y., by D. H. Matheson, Chemist and Bacteriologist, Hamilton Filtration Plant, Hamilton, Ont.

THE difficulties attributable to algal growths constitute a perennial problem to the operators of treatment plants using surface waters as a source of supply. Each year these troubles must be overcome or endured. It is well to take stock, from time to time, of the preventive or ameliorative techniques that are available to minimize the plant difficulties and the public complaints arising from this recurrent phenomenon. In this paper, the subject will be considered particularly from the point of view of the small-plant operator who does not have expert technical advice at his immediate disposal, but who is expected, nevertheless, to know at least the possible courses of treatment that may be applicable to his situation.

The operator of a plant subject to algae troubles should make an effort to acquire some knowledge of these organisms. Of the many hundreds of algae species that occur in appreciable numbers in natural waters, comparatively few—perhaps a dozen or a score, at most—are regular causes of treatment plant difficulties. It is possible to learn to identify these with only a little training, as one learns to recognize the common wild plants and animals of the macroscopic world. Simple counting methods can be used to indicate roughly whether the population density of an algal species is great enough to account for the operational difficulties that may be experienced.

Training of this nature is one of the most obvious advantages accruing from attendance at short schools for water works operators. It is highly desirable to know and recognize the causitive organisms rather than to treat blindly the symptoms observed in the plant. Some of the objectionable symptoms that are usually the effect of algae may occur in the complete absence of the organisms. It is evidently futile to take measures directed against algae it they are not the source of the difficulty.

The two most serious effects of algae in water treatment are interference with filtration and production of objectionable tastes and odors. The filter difficulties are generally due to a rather limited group of filter-blocking diatoms, although a few other organisms are occasionally present in sufficiently large numbers to be troublesome. The tastes and odors are caused by a wide variety of algae, the intensity and quality varying with the species concerned. Many organisms, especially the blue-green algae, produce more offensive odors when dead and decomposing than when alive.

Control of Algal Growth

Where the source of a water supply is a moderately sized body of stored

water, either natural or artificial, direct chemical or biological interference in the cycles of growth of objectionable algae may often be advantageously undertaken. These control measures include reduction or limitation of the nutrient supply available to the organisms for their multiplication, the alteration of the physical conditions of the environment, such as the reduction of light intensity, and the planned destruction of algal populations by the use of algicidal chemicals.

The quantity of algae produced by a body of water—its productivity—depends on, among other things, the store of plant nutrients available to the organisms. These nutrients are contributed to the water from three main sources: the influent streams and the drainage from agricultural land; the addition of treated or untreated sewage; and the re-solution of mineralized nutrients from the decaying organic detritus on the bottom.

The access of nutrients in the influent streams and land drainage cannot be controlled unless the whole watershed can be managed and controlled as a unit. When this is possible, as it often is with watersheds in isolated, sparsely populated areas, significant limitation of plant food supplies may be achieved.

Domestic sewage contains large amounts of plant nutrients, particularly nitrogen and phosphorus, and may be expected to stimulate algal growths in the receiving waters. Ordinary sewage treatment does not remove appreciable quantities of these nutrients. Processes specifically designed to effect such reductions are of considerable research interest at present.

Of the elements essential for algal growth, phosphorus is the one which is present in waters in the smallest concentration, and which is therefore the one most likely to be depleted by algal growth, thus limiting the total algal crop. Sawyer (*1*) has recently pointed out that the phosphorus content of domestic sewage has probably doubled in the last 6 years, owing to the phenomenal growth in the use of synthetic-detergent compounds that contain much phosphate. It is quite likely, therefore, that sewage additions to water supplies will become increasingly more effective in causing large growths of algae than heretofore. Every care should be taken to minimize the access of nutrients through this agency.

Waters that are naturally high in nutrient level cannot be expected to show large decreases in plankton growth as the result of the removal of additional sources of nutrients.

In small presedimentation basins, control of the proliferation of algae may be obtained by restricting the entry of light. Covering such basins would no doubt be the ideal solution, but this is generally not economical for those of great size. The use of powdered activated carbon to reduce the penetration of light was instituted in the United States in 1939 and has attained wide popularity, especially throughout the midwestern states. The application of the carbon is quite simple; the quantities required are moderate and inexpensive; there is slight danger of ill effects through overtreatment; and some additional advantage may accrue through the adsorptive power of the carbon. There can be little doubt of the effectiveness of this treatment, as attested by its wide and continued use, but there is some uncertainty about the mechanism involved. It appears that the reduc-

tion of light intensity actually realized is not sufficient to account for the improvements noted in plant operation.

Control of algae by the use of algicidal chemicals remains one of the standard methods of attacking this problem. Copper salts are still the only material widely employed, but research work is being prosecuted to find new, and perhaps more effective and specific, agents, especially in the field of organic chemicals. As the algae concerned are difficult to culture in the laboratory, it should not be too hard to discover some means of altering their natural environment to prevent their growth.

Chemical intervention in the biological system of the water should not be undertaken without due consideration of all the factors involved—the severity of the need, on the one hand, and the possible disadvantageous consequences, on the other. Treatment postponed too long may become inadvisable, owing to the deleterious effects of the release of a sizable quantity of organic matter after the destruction of a large algal population. A copper-resistant alga, generally one of the *Chlorophyceae*, frequently develops when a diatom population has been destroyed, and causes more difficulty than the original growth.

Copper sulfate is the salt most commonly used in algicidal treatments. Copper citrate, in the form of a proprietary preparation, appears to have some advantages under certain conditions, but there is little technical information available to demonstrate its superiority.

In relatively small basins, and, particularly, in filtered-water reservoirs, chlorine has some value as an algicide and is effective against organisms that have a marked resistance to copper. The disadvantages include the difficulty in applying chlorine evenly to large bodies of water, the large amounts required if the water has an appreciable chlorine demand, the rapid dechlorination that takes place when the water is exposed to sunlight, and the considerable danger of causing an increase in taste and odor through the formation of chloro compounds. Some of these deficiencies can be avoided with chloramine.

Copper and chlorine together are more effective than is either alone, and a combination of chlorine, copper, and ammonia, first used by Harold in England in 1934, has lately been employed by Smith at Richmond, Va., for the control of algae and other organisms in open service reservoirs and in the distribution system (*2*).

In France, a novel process of "electrocution" is used for controlling the growth of algae in water applied to slow filters. An a-c field of approximately 90 v per inch is established between electrodes in a narrow channel, through which water flows at approximately 1 fps. The algal cells are killed by the passage of the current through the water and do not multiply in the water on the filters. The process is used in one small municipal plant and has been proposed for a new one.

Algae and Filtration

When the source of supply is a river or a large lake, or when, for some reason, control of the algal growths in the water supply is not feasible, the purification plant must treat the algae-containing water as it comes to the plant. Removal of the algae by efficient coagulation and sedimentation is the ob-

vious procedure, but it is attended with great difficulties.

The addition of coagulant frequently appears to make filtration more difficult, as the natural buoyancy of the algal cells prevents rapid sedimentation of the floc, and the filter load is increased. Many have reported that continued use of coagulants was practically impossible. Baylis and Gerstein (*3*) consider that certain algae add toughness to the flocculated particles deposited on the filter sand and thus tend to form a tenacious and impermeable mat on the sand surface.

Increasing the coagulant dose sometimes helps to overwhelm the buoyant effects of the algae with an enormous amount of floc. This method is obviously very expensive, especially when it is considered that water containing algae is usually very clear and requires little coagulant for clarification. It is not unusual to find that increasing the coagulant dose does little to improve filtration.

The addition of material such as clay to produce artificial turbidity aids in sedimentation by increasing the density of the floc and has been so used on several occasions. Baylis has offered the useful suggestion that, in waters like the Great Lakes, which are saturated with calcium bicarbonate, the addition of a small quantity of lime would cause the precipitation of an additional amount of calcium carbonate and economically provide a heavy material to weight the floc.

Activated carbon, when added before or with the coagulant, is effective in producing a more settleable floc, as has been demonstrated at Chicago (*3*). Utilizing carbon in this manner for lengthening filter runs is an expensive procedure, but, as its use is required only for a comparatively short time during the year, the annual cost of water treatment is not unduly increased. The convenience of using a material that is already at hand, and for which feeding and handling equipment is already provided, makes it preferable to clay as a coagulant aid.

The improved coagulation that silica sols provide under certain circumstances has been used to a limited extent in attempts to remove algae.

The heavier floc produced by coagulation with iron salts makes these materials attractive in coagulating waters containing algae. Where plant-scale experiments have been performed, the advantages of iron coagulation have usually not been great, however, and have been overbalanced by the additional cost and the difficulties in handling and application. Alum has ultimately been found preferable as a coagulant.

The use of copper sulfate applied with coagulants is frequently mentioned as a means of improving filter operation. With motile organisms or those that tend to disintegrate when killed, the treatment appears to be effective, but, with diatoms, the dead cells do not seem to be removed by coagulation any better than do the living.

Prechlorination generally appears to be the most effective method of aiding coagulation in the presence of algae, particularly when the organisms are susceptible to disintegration by the chlorine. At Windsor, Ont., short filter runs caused by diatoms were much improved by prechlorination, especially when a free chlorine residual was produced.

Algae-containing waters that are to be treated on slow filters are fre-

quently passed through coarse rapid filters first, to remove the greater portion of the algal load. In England, a unique process of microscreening has been developed commercially to pretreat these waters, in place of the bulkier roughing filters (*4*). The screening membrane, a stainless steel fabric with apertures as small as 35 μ, is mounted on a continuously rotating drum, through which the water flows. The screen is continuously washed with approximately 1 per cent of the treated water. The larger diatoms are almost completely filtered out, and the overall removal is better when the water contains large amounts of suspended matter, because the heavy mat formed on the screen increases its effectiveness. When water supplies are free of color and turbidity and require treatment only for removal of plankton, microstraining may possibly be used alone.

Sanchis has recently discussed the development of diatomite filters designed solely for the purpose of removing plankton from otherwise clear waters.

Operators of conventional rapid sand filters, when treating clear water containing only algae, find it best to use no coagulant. If the sand is not too coarse, most of the diatoms and other algae are removed, and if the turbidity of the raw water is not too high, preferably under 5 ppm, an acceptable quality of output can be maintained. Frequent short washes are sufficient to remove the algae from the filter, and the use of an above-normal quantity of wash water is a more economical way of removing the algae than is additional chemical treatment. This procedure has been used with satisfactory results at Hamilton, Ont., for more than 15 years. The turbidity of the filter effluent is kept below 1 ppm, a concentration that is not high enough to cause complaints. The wash water used during the algae season amounts to approximately 5 per cent, but, for short periods, it has risen as high as 10 per cent.

Tastes and Odors

Algae, living or dead, often most conspicuously affect water supplies by the production of tastes and odors. These vary in intensity and in quality from the not too objectionable fresh-vegetable and aromatic odors of many living algae to the highly offensive pigpen odor of decaying blue-green algae. As little is known about the exact nature of the chemical substances in the water that are responsible for the production of tastes and odors, progress in the development of ameliorative treatments has been on a purely empirical basis.

Chlorination in the usual moderate dosages generally has the effect of intensifying the odors of algae. Hale (*5*) attributed this fact to the freeing of the "essential oils" on the death and disintegration of the algal cells. Some organisms liberate substances that, on chlorination, produce tastes highly medicated in character and practically indistinguishable from chlorophenol derived from industrial wastes.

From the standpoint of palatability, disinfection of water with chloramine is desirable because it minimizes the intensification of odors and, in general, aids in the removal of the odorous substances by activated carbon.

Superchlorination is effective against algal tastes and odors in varying degrees, depending on the algal species, the chemical properties of the water,

and the peculiarities of the individual treatment plant. Superchlorination is particularly effective against the odor of *Synura*. The odors of diatoms, *Anabaena*, and *Dinobryon* are reduced, especially on long contact, but are not completely removed. Superchlorination requires much more careful chemical control for its successful operation than other treatments do, and it may produce highly odorous nitrogen trichloride in waters containing a large quantity of albuminoid ammonia.

Chlorine dioxide is now widely used for the control of tastes and odors and is very effective in removing chlorophenolic odors of industrial origin. Removal of strictly algal odors is accomplished with greater difficulty and by substantially higher dosages. Chlorine dioxide is the most effective treatment for removing the odors attributed to actinomycetes.

Ozone is the strongest oxidant commercially available for water treatment plants. It has attained its widest use in France, where a total of more than 160 mgd is ozonated. It is used there primarily for its bactericidal properties, but its oxidizing power for color and odor removal is recognized. The large ozonation plant at Philadelphia was designed primarily for taste and odor reduction, as, in the limited detention period possible, it was not feasible to control treatment by free residual chlorination. Ozone effected similar oxidation after a few minutes of detention. Ozonation requires much more expensive equipment than chlorination, a considerable deterrent to its use in the United States and Canada, where there is no strong aversion to the employment of chlorine. Ozone, however, completely avoids the danger of intensifying odors by the production of chlorinated compounds.

No method of taste and odor removal has attained widespread acceptance as rapidly as activated carbon. This treatment has outstanding advantages over chemical methods. It is effective, at economically justifiable dosages, against almost every type of compound producing tastes and odors. Thus, it is not necessary to determine the exact cause and source of the offending material before treatment can be prescribed, whereas other methods may be applicable only to a limited class of substances. Carbon is simple and easy to apply. Although dosages of 2–5 ppm are usually effective, enormously greater amounts can be applied without danger of causing serious harm. And by no means the least of its advantages is the fact that its use appears to meet with the water consumers' approval, which is seldom accorded to other chemicals.

The principal problem in the use of activated carbon is the determination of the most economical dose. Sometimes very large dosages are required, amounting even to 100 ppm, but these may be justified because the need for such treatment is usually of short duration. The efficiency of carbon treatment depends upon a number of factors. Adsorption is generally poorer at a higher pH. Chlorination may aid or hinder adsorption, depending on the nature of the odorous substance, and carbon is usually more effective with chloramine than with chlorine. In filtration plants, carbon may be used before coagulation, in which event coagulation may be improved and the sludge accumulating in the sedimentation basins stabilized. Carbon may also be added after coagulation, giving

the floc an opportunity to remove some of the offending material first. Suspended carbon carried to the filters is very effective in the adsorption of odors, although some shortening of runs may occur.

Limited use is made of activated carbon in water where no filtration is provided. At several places in the United States where impounding reservoirs or small lakes have been heavily infested with algae, copper and carbon were used to remove the growth without producing objectionable tastes. In Winnipeg, Man., up to 2.5 ppm has been used in service reservoirs without causing difficulties, although higher doses are noticeable to the consumer.

Conclusion

The regular seasonal pulses of algae may cause serious difficulties in the operation of water purification plants. Although troubles may be unavoidable, they should not be considered insuperable. The battle against algae can be joined at several points.

The concentration of algae in the incoming water may be lowered by avoiding unnecessary fertilization of the supply, or by interfering with the multiplication of the organisms by physical or chemical means. Once in the plant, the algae can be removed by improving the efficiency of coagulation. Microscreening offers interesting possibilities. Filtration without coagulation, and with the abundant use of wash water, is a cheap and effective procedure when applicable. A variety of treatments to combat offensive tastes and odors are available. These range from the powerful oxidants designed to destroy the odorous materials chemically to adsorbent carbons that remove the offending substances physically.

The deleterious effects of algae can be overcome. It is more often a question, depending on the severity of the conditions, of what expenditure is justified.

References

1. Sawyer, C. N. Some New Aspects of Phosphate in Relation to Lake Fertilization. *Sew. Ind. Wastes*, **24**:768 (1952).
2. Smith, M. C. Copper With Ammonia and Chlorine in Finished Water. *Jour. AWWA*, **43**:763 (Sept. 1951).
3. Baylis, J. R. & Gerstein, H. H. Microorganisms in Lake Michigan Water. *Munic. News & Water Works*, **76**:291 (1929).
4. Hazen, Richard. Application of the Microstrainer to Water Treatment in Great Britain. *Jour. AWWA*, **45**:723 (July 1953).
5. Hale, F. E. *The Use of Copper Sulfate in Control of Microscopic Organisms.* Phelps Dodge Refining Corp., New York (1939).

Raising an Elevated Storage Tank

By Harry J. Draves

A paper presented on Feb. 13, 1953, at the Indiana Section Meeting, Indianapolis, Ind., by Harry J. Draves, Supt., Dept. of Water Works, Michigan City, Ind.

MICHIGAN CITY, Ind., was recently faced with the unusual problem of raising an elevated storage tank. In 1952 the water department completed a construction program that included a new 1-mil gal elevated tank. This structure was built near an industrial area in which the pressure had not been too good. Therefore, in designing the new tank, it was felt that it should be of sufficient height to increase the static pressure in the area approximately 10 psi. To do this, it was necessary to raise the existing 750,000-gal tank 20 ft, so that the elevation of both tanks would be the same.

The local press announced the plan to raise the tank, and the department began getting inquiries on how the work was to be done. The author was as curious about the matter as the ordinary citizen and found the actual procedure used by the contractor, the Chicago Bridge and Iron Co., extremely interesting.

Before the work could be started many hours had to be spent at the drawing board and much engineering skill was required to lay out the job so that it could be done in a safe and efficient manner. All of the jigs used were designed for the work at hand, and all of the materials employed had to be checked for perfect fit.

The tank, erected in 1934, was of two-panel design with eight H columns. The original overall height was 85 ft, and the weight was approximately 215 tons. Figure 1 is a photograph taken before the tank was raised.

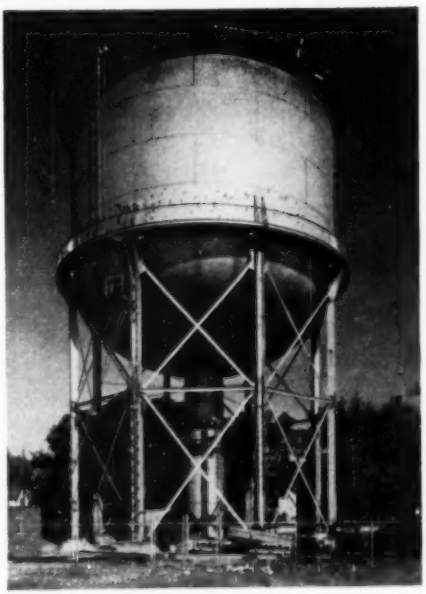


Fig. 1. Tank Before Operation

Erected in 1934, the 750,000-gal tank was of two-panel design, had an overall height of 85 ft, and weighed 215 tons.

The first step in the operation was to weld approximately 580 lifting lugs on both sides of the old columns at

predetermined places. After the welding had been completed, the columns were partially cut at the base. Wedges were then driven into the cut portion (Fig. 2) and burned off flush with the outside of the column.

After the first cuts had been made on the old columns, new, latticed box columns were placed around them. Three sides of the new columns had already been welded together, and it was necessary only to weld the face plate on after emplacement. After the new columns had been welded to the old base plate and the jacks set, the uncut portions of the old columns were severed, as indicated by the broken lines in Fig. 2. The jacking then proceeded, with the box columns serving as sleeve guides during the raising process.

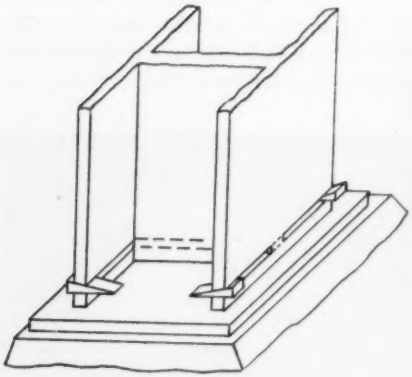


Fig. 2. Cutting of Columns

After the first cuts (indicated by solid lines) had been made in the old columns, wedges were driven in and burned off flush with the outside of the column. When the new columns were all in place and the jacks had been set, the final cuts (shown by broken lines) were made, to sever the old columns from their base.

The new bottom panel is 3 ft shorter than the original one. This fact permitted complete assembly of the new panel, including columns, struts, diagonals, and cylinder rods, before the jacking actually started. Eight jacks like the one shown in Fig. 3 were used to raise the tank. These jacks were of 50-ton capacity with a 14-in. lift, and all were operated simultaneously. The theoretical dead load on each jack was approximately 27 tons; the sleeve friction and wind loads, however, made the actual figure considerably greater. The jacks were mounted on top of the new columns and remained in that position throughout the raising procedure.

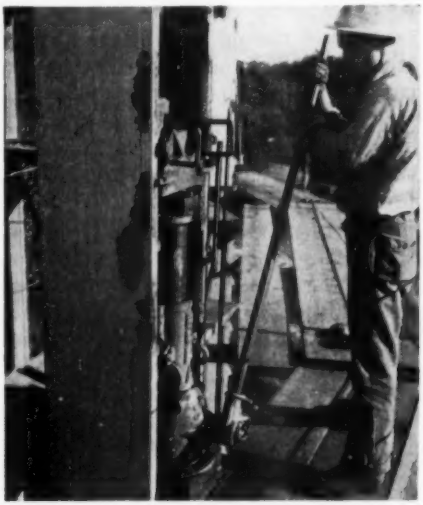


Fig. 3. Jack in Place

Eight of these jacks—one on each column —were operated simultaneously. The theoretical dead load on each jack was approximately 27 tons.

The jacks exerted their force against load-equalizing blocks. These delivered the force to latches (Fig. 4), which, in turn, transferred it to the

plate lugs previously welded to the old columns. The latches were held firmly in place by a wedgelike jib key, which is clearly visible in Fig. 4. This picture also shows the portable height gages, one of which was clamped to every column and used to record the lifting progress of each cycle of jacking. These gages enabled the crew to keep the tank level during the raising process, as well as to make sure that the jacks remained equally loaded. The pointed rod was attached to the top of the new bottom column, and the scale to the old bottom column.

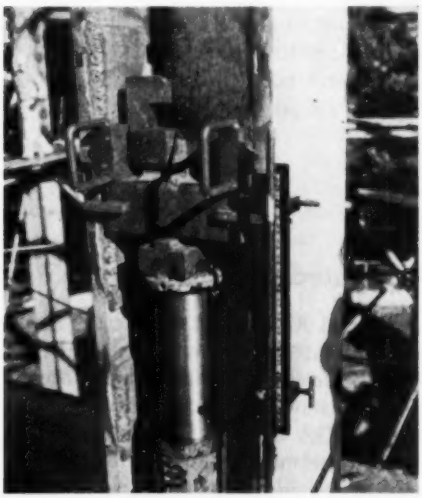


Fig. 4. Jacking Arrangement

The jacks exerted their force against load-equalizing blocks, which delivered the force to portable latches (equipped with handles). These, in turn, transferred the force to the plate lugs previously welded to the old columns. A wedgelike jib key kept the latches in place.

Approximately 40 strokes were required on each jack to raise the tank 1 in. After the tank had been lifted 11 ft, short diagonals, with turnbuckles, were installed temporarily (Fig. 5), making the tank safe for wind loads up to 60 mph during the remainder of the raising process. When the tank reached the required height, these members were replaced by full panel diagonals.

Fig. 5. Tank Being Lifted

The tank is shown after it had been raised 11 ft. To raise the tank the planned 20 ft required 3 days.

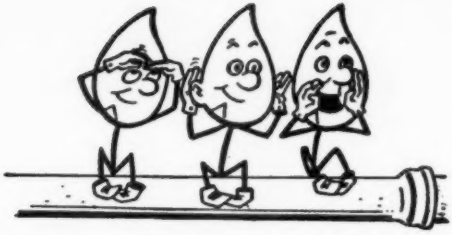
A holding mechanism, basically the same as the jacking-block arrangement, was employed on the inside of each column. Its purpose was to maintain the tank in a partially raised position while the jack ram was lowered one space to engage the next set of column plate

lugs. After the tank had been raised the full 20 ft, the distance the original columns were sleeved into the new ones was approximately 4 ft, and the old and new columns were then welded together. Shields were welded on the old H columns at points immediately above the new ones to divert any rain water to the outside of the new columns. The lifting lugs that had been welded to the old columns were left in place, as it was believed that the expense of removal would be too high.

The preliminary work, such as welding the lifting lugs to the old columns, cutting the old columns, bracing the new columns, and preparing temporary trusses, took approximately 5 weeks, while the actual raising of the tank required only 3 days. The total cost of the job—including sand blasting the inside of the tank, completely cleaning the outside with power tools, and painting the entire structure—amounted to approximately $50,000, or 40 per cent of the cost of a new tank. This difference in cost makes the lifting procedure well worth considering for utilities in similar situations.

Fluoridation Stand Reiterated by ADA

At the annual convention of the American Dental Assn., Sept. 28–Oct. 1, 1953, its House of Delegates, by unanimous action, reiterated the recommendation that "all local communities be urged to adjust the fluoride content of their public water supplies to the level recommended by responsible state and local health authorities." The action followed a report from the ADA councils on dental health, dental research, and dental therapeutics, whose "continuing evaluation of evidence relating to fluoridation led to their conclusion that all additional scientific findings further substantiate the effectiveness and safety of fluoridation under properly controlled conditions." "This evidence," the report stated, "continues to demonstrate that fluoridation will have no untoward effect on general health and will significantly improve health through the reduction of dental decay." With regard to those who oppose fluoridation, the report asserted that the opponents were using "false, misleading, and emotional charges against fluoridation based on undocumented and unscientific supporting material."



Percolation and Runoff

Taking water for granted is something that water works men have always ascribed to their public, but what *Water and Water Engineering* wants to know is whether they, themselves, are not, perhaps, inclined toward the same fault. It was in a discussion of the desirability of a British Standard Specification for water that the editors pointed out that pressure to establish specifications usually comes from the manufacturers involved and wondered if water utilities really were so much less interested in their product that they had made no effort to have it standardized. That, of course, lets us out. We *have* a standard—issued by Public Health Service and accepted by AWWA—which at least morally enforces the production of an undangerous drink. Is that enough, though, or should there be encouragement of something more positive than non-sickening getdownability?

The British suggestions for standards are: Grade III—pure water; Grade II—pure, softened water; Grade I—pure, softened, low-temperature water; Super-Grade—fluoridated, pure, softened, low-temperature water. Regarding specific grades, of course, we have a few ideas of our own, but for sure, we'd start with Grade A (safe) and work up. Then, too, we'd certainly want to integrate the grading with the rate structure. After all, the consumer who gets safe water saves doctor bills, soft water saves soap, cold water saves ice (or, anyway, gets a better drink), and fluoridated water saves dentist bills. Some of that saving, at least, ought to be shared with the utility that makes it possible. We see some difficulty, of course, in all those "acts of God" that affect the raw water to be treated, but then, what does a dairy do when its herd happens on some wild onions? And if water supply for fire protection can be graded into categories suitable for use as a rate base, water supply for domestic purposes ought to be even easier to classify and assess—by a meter, for instance, that records quality as well as quantity.

What we're suggesting, we suppose, is antinegativity of approach. Not just water that can safely be taken for granted, but water to be appreciated for all that it is and does—and can get you!

Pollution control programs in New York State have been started in 23 drainage basins with an area of 8,800 sq miles, according to the Water Pollution Control Board. Thus, since the program was initiated in 1949, work has been begun and is in various stages of progress in nearly 20 per cent of the State's area.

(Continued on page 34 P&R)

(Continued from page 33 P&R)

What can happen when water bacteriology becomes the center of a political controversy was illustrated by some stormy sessions of the Livingston, N.J., Township Committee meeting last September. It seems that Township Health Officer Herbert Cannon took it upon himself to test the local water supply, and, backed by a group of anti-Committee citizens, promptly advised residents to boil their water. The Committee, led by Mayor Andrew Axtell, angrily accused the opposition of irresponsible political maneuvering, and offered in evidence the reiterated finding of State Health Dept. officers that the water supply was not contaminated. Crux of the matter appears to have been the failure of Cannon, Grady, et al. to use "Standard Methods" for detection of *Esch. coli;* the "outmoded" tests they used, according to the State Health Dept., were for organisms without sanitary significance.

So fearful has modern science or its popularization made the general public of anything microscopic, however, that the township is flushing its dead ends. And, although the Committee has advised the public not to follow Cannon's advice to boil water, it seemed when last heard from that the Committee would be in hot water aplenty until either the opposition or the general public brushed up on its bacteriology.

"The best water supply in the world" is what the rather reserved Water Companies Association recently claimed that Britain has developed. The fact that the claim was made in arguing against the Labor Party's case for nationalizing or regionalizing British water supplies may, perhaps, account for the rather uncharacteristic positiveness of the position. Here in the U.S., of course, almost every public water supply is "the best in the world," but, then, that's rather different. What we know we mean is "best," at best, "in some respect" or, at worst, "best for us." Only in one respect—that of percentage of total population served—are we willing to admit that Britain's best is even bester than our own. No less than 95 per cent of Britain's populace enjoys "a public supply of pure water," whereas our best is a none too good 67 per cent. Aside from this, however, Britain's "best" seems to us more in danger of nationalism than nationalizing.

A "for sale" sign was hung on the lime plant of the Board of Water & Electric Light Commissioners, Lansing, Mich., which needs the site for a much larger, 36-ton plant. The plant being offered has a capacity of 5 tons per day and includes a centrifuge, two-stage drying system, furnace, and instruments and controls, all in operating order. A $23 \times 28 \times 45$ ft high building, with a steel frame and aluminum siding, is also included. The plant produces hard, high-grade lime pellets (CaO) from water softening sludge.

(Continued on page 36 P&R)

No Place for Tastes

No one yet knows the exact chemical composition of algae, but it is common knowledge that algae cause a good part of all the tastes and odors in water supplies. These algae-caused odors are characterized as fishy, aromatic, grassy, earthy, etc. In most cases when Threshold Odor Numbers exceed 5, consumer complaints can be expected.

Algae tastes and odors are attracted to the surface of Aqua Nuchar and held there by strong forces. When the Aqua Nuchar is removed by sedimentation or filtration the tastes and odors are also removed. Complete removal of tastes and odors is better than masking them by a chemical change.

Write to our nearest office and arrange to have one of our Threshold Odor Experts re-evaluate your taste and odor problem in line with the latest procedures developed by our Technical Service Department.

industrial CHEMICAL SALES

division west virginia pulp and paper company

New York Central Building
230 Park Avenue
New York 17, N. Y.

Pure Oil Bldg.
35 E. Wacker Drive
Chicago 1, Illinois

Lincoln-Liberty Bldg.
Broad & Chestnut Sts.
Philadelphia 7, Pa.

2775 S. Moreland Blvd.
At Shaker Square
Cleveland 20, Ohio

(*Continued from page 34 P&R*)

A water resources steering committee has been formed to aid the Mid-century Conference on Resources for the Future that will be held in Washington during December. Sponsored by Resources for the Future, Inc., and supported by a Ford Foundation grant, the Conference has as its object the assembly of facts and viewpoints of both industry and conservation groups on natural resources. No program will be endorsed by the Conference, but it aims to lay a groundwork for the intelligent adoption of policies and programs by others. The nine-man steering committee on water resources is headed by Gilbert Fowler White as chairman and Abel Wolman as co-chairman.

Chairman White is president of Haverford College and was a member of the Committee on Natural Resources of the Hoover Commission, the National Resources Planning Board, the Committee on American Participation in the UN Conference on Conservation, and the President's Water Resources Policy Commission, of which he was vice-chairman. As an AWWA past-president, Abel Wolman is well known to most JOURNAL readers, but it may surprise some to learn that he also had time to serve as chairman of the sanitary engineering committee of the National Research Council's Div. of Medical Sciences and chairman of the Engineers Joint Council coordinating committee on national water policy.

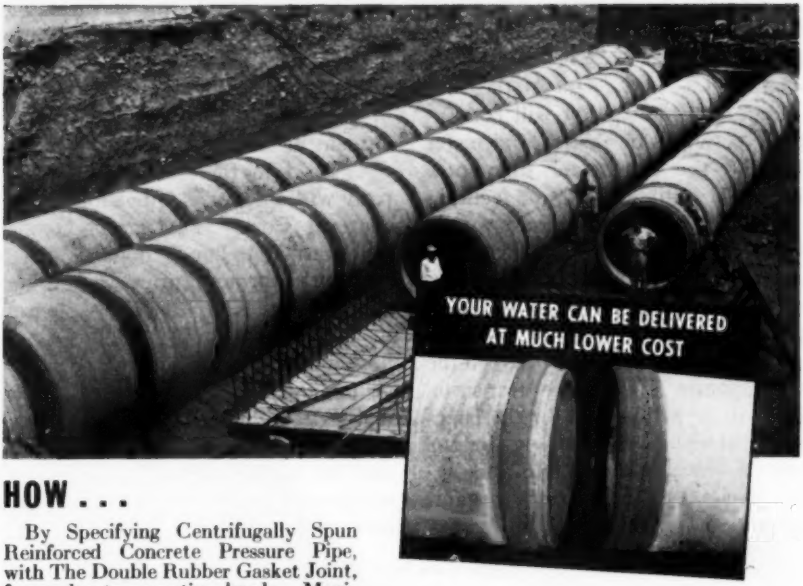
Other members of the steering committee are Jean S. Breitenstein, Denver attorney who is a member of the Natural Resources Committee of the U.S. Chamber of Commerce; J. M. Clark, Columbia University professor of economics who acted as consultant to the National Resources Planning Board; Claude E. Kelley, oil company executive and president of the National Wildlife Federation; Warren T. Hannum, chairman of the California State Water Pollution Control Board and, until his retirement as a major general in 1944, a Corps of Engineers officer active in rivers and harbors development; W. W. Horner, of Horner & Shifrin, widely known as a consultant but also noted for his work as a member of the National Resources Planning Board's national water committee and the Engineers Joint Council panel; Samuel B. Morris, head of the Los Angeles Dept. of Water and Power and AWWA past-president, who has served on the President's Water Resources Policy Commission and the National Resources Planning Board; and Charles A. Sprague, Salem, Ore., newspaper publisher and former governor of Oregon.

Rossiter M. Scott, consulting water works engineer for Dresser Mfg. Div. of Bradford, Pa., died at Baltimore, Md., on September 1, at the age of 77. He had been in retirement since 1948. In addition to some early work with Baltimore power and shipbuilding companies, Scott had been connected with Nicholas Hill Associates as a water works consultant, and traveled extensively, particularly in Asia. He joined the Dresser organization in 1932.

Art Concrete Works, manufacturer of precast valve and meter boxes, has changed its name to Brooks Products, Inc. There will be no change in the organization or its policies, according to President Frank M. Brooks, who attributes the dropping of the old name to the fact that the manufacture of ornamental garden benches and bird baths is no longer the chief activity of the 43-year-old concern.

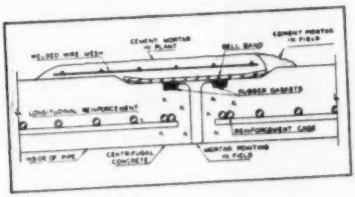
(*Continued on page 38 P&R*)

THIS PIPE CAN SAVE YOU MONEY



HOW . . .

By Specifying Centrifugally Spun Reinforced Concrete Pressure Pipe, with The Double Rubber Gasket Joint, for moderate operating heads. Maximum operating heads range from 100 ft. to 150 ft. depending upon pipe diameter and operating conditions.



A watertight closure, simple in design, flexible and positive in service. Joints may be pulled to allow for minor changes in line or grade. Angle joint bands provided for larger deflections. This joint was developed by American to insure ease and speed of installation.

WHY . . .

1. *FREEDOM FROM MAINTENANCE.*
2. *SUSTAINED MAXIMUM CARRYING CAPACITY.*
3. *EASE OF INSTALLATION.*
4. *PERMANENCE.*
5. *LOW FIRST COST.*

Rely on American Pipe and Construction Company's 45 years of know-how in this field. Our experience, our informative booklets and our sales engineers are as near as your telephone.

American
PIPE AND CONSTRUCTION CO.

Concrete Pipe for Main Water Supply Lines, Storm and Sanitary Sewers, Subaqueous Pipe Lines

P. O. Box 3428, Terminal Annex, Los Angeles 54, California

Main Offices and Plant—4635 Firestone Blvd., South Gate, Calif.

District Sales Offices and Plants — Oakland • San Diego • Portland, Ore.

(Continued from page 36 P&R)

The Rensselaer Valve Co. of Troy, N.Y., formerly a subsidiary of Neptune Meter Co., has been sold to an investment group of New York and Ohio businessmen. As a result of the sale, the Neptune organization will concentrate its activities on meters and meter parts, and the Rensselaer firm, now independent, will expand its facilities for producing large water works valves. Lyman C. Thunfors, who was vice-president and general manager of Rensselaer when it was affiliated with Neptune, has been elected president of the company. Cooperation between the two companies during the transition period will be maintained for the benefit of customers, particularly in the matter of warehousing valve and hydrant stocks by the Neptune organization.

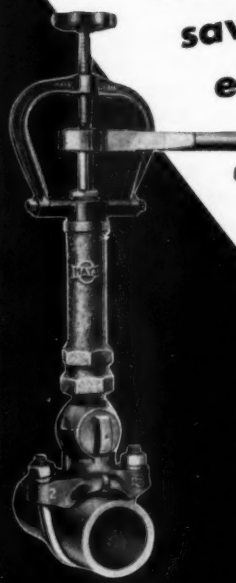
Elgin-Refinite, Inc., will be the new name under which will be offered the industrial water conditioning products and services of Refinite Sales Co. of Omaha, Neb., and Elgin Softener Corp. of Elgin, Ill., as the result of a recent agreement between the two organizations to join forces. The new company will operate as a division of Elgin Softener Corp. The parent company will continue to handle household water softeners through franchise dealers. The Refinite Corp. will also continue to manufacture and distribute its own household water softeners and also its swimming pool accessories. The joining of the industrial water conditioning lines under the Elgin-Refinite name is said to round out and reinforce the equipment and experience available to customers.

(Continued on page 40 P&R)

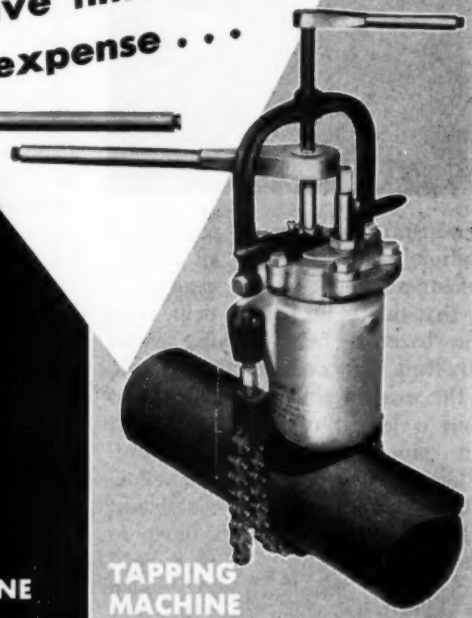
Water Softening
& Iron Removal*
Deluxe
JUST WHAT YOU'VE BEEN WAITING FOR—
Complete Water Softening
Complete Iron Removal*
Fully Automatic Operation
All in one single, compact, highly efficient water conditioning plant
Low in cost too—
*Including H2S removal when required
"See us at the CHEMICAL INDUSTRY SHOW — Philadelphia — November 30 through December 5."
Write for FREE Bulletins
H & T SERVICE
HUNGERFORD & TERRY, INC.
CLAYTON 5, NEW JERSEY

HAYS

AMONG THE HAYS WATER WORKS PRODUCTS that you need to save time and expense . . .



DRILLING MACHINE



TAPPING MACHINE

Write for literature, or ask "The Man from Hays"

(FOR OVER 80 YEARS)

CORPORATION STOPS • CURB STOPS
SERVICE BOXES • FITTINGS
BRANCH CONNECTIONS • GOOSENECKS

HAYS

WATER WORKS PRODUCTS
HAYS MANUFACTURING CO.
ERIE, PA.

(*Continued from page 38 P&R*)

The "Starboard Arms" position of our adjoining friend, if not all the unbuttonedness, ought to be a dead giveaway that this is no G.I. at drill, even if the bazooka he's carrying looks strictly legit. Unconfidentially, though, even the weapon ain't what it looks to be, but a length of perforated black Tenite pipe, machine-wrapped with wire-like stripping of translucent yellow Tenite to make a corrosion-resistant well screen for use in wells down to 200 ft in depth. The Southwest Well Screen Co. of Jonesboro, La., which made the 5-ft length of 4-in. diameter screen, claims it to be as tough as its carrier looks, resistant to shattering, oils, greases, heat, and humidity as well as to corrosion and incrustation. Anyway Southwest would like the next command to be "Order Arms" and doesn't care much whether you do it left- or right-handed.

Kenneth W. Cosens, associate professor of civil and sanitary engineering at Ohio State Univ., has been appointed acting chairman of the department, succeeding George E. Large, who resigned to devote his full time to teaching and research. Cosens taught previously at Michigan State College and the University of Texas. After coming to Ohio, he organized the annual Ohio Water Clinic.

What price water seems to be a different kind of question in Texas than anywhere else. There the answer is definitely not peanuts. Perhaps it's the drought-inspired appreciation of water. Perhaps it's the oil economy. Or perhaps it's just another example of Texas bigness. But when Houston water bills bring in as much as $3,000 worth of bad checks in a week and can cause a landlord to shoot one of his tenants for merely watering his lawn, we begin to wonder if we're talking about the same zero proof stuff that flows through other water mains. It isn't even entirely assuring to have Henry Wilkens, Houston district manager of the Texas Water Co., tell us that check bounce can be brought under control quickly by shutting off the supply and that murder is only one way by which high water bill complaints are settled. Forget the Alam, just remember the *eau!*

G. M. C. Lucas has joined the Layne-Atlantic Co. and will act as sales engineer in the Water Treatment Div. at Orlando, Fla.

J. B. Converse, having seen the Mobile, Ala., consulting firm of J. B. Converse & Co. through its twenty-fifth anniversary, will relinquish his post of president on January 1, 1954, to become board chairman. H. E. Myers, now vice-president, will become president.

(*Continued on page 42 P&R*)

Why Wait

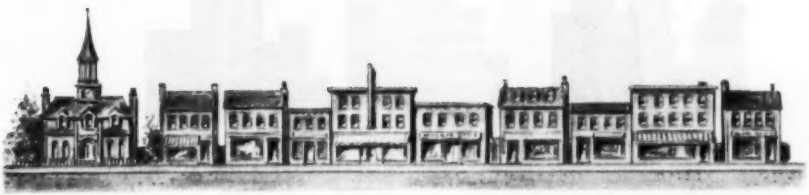
for a modern water conditioning plant?

An abundant supply of clear soft water frequently determines the growth of a city.

Many municipalities postpone the advantages of a good water supply because costs based on older, conventional designs are beyond their means.

In many towns and communities, Graver water treatment plants have shown that such treatment can be supplied at moderate cost and on a self-paying basis.

Graver installations are simply designed and with a practiced eye on cost and space saving features. Moreover, these modern installations produce considerably improved results—compared with older equipment—and frequently at lower chemical, labor, and maintenance costs. Bulletins available on request.



GRAVER WATER CONDITIONING COMPANY

Division of Graver Tank & Mfg. Co., Inc.

Dept. AWW-R, 216 West 14th Street, New York 11, N. Y.

Cold Process Softeners and Coagulators • Filters and Iron Removal Plants
Sodium Zeolite Softeners • Swimming Pool Equipment • Boiler Feedwater Equipment

GRAVER
EQUIPMENT FOR ALL WATER AND WASTE TREATMENT PROCESSES

Municipal Water Conditioning

GW483A

(Continued from page 40 P&R)

Howard E. Moses, director of the Bureau of San. Eng. in the Pennsylvania Dept. of Health and chairman of the Conference of State Sanitary Engineers, has been appointed chairman of the Ohio River Valley Water Sanitation Commission.

Edward D. Flavin has been made manager of the new Public Utilities Section of Johns-Manville Corp., and will offer special service to utility users of J-M products.

J. Delano Hitch Jr., executive vice-president of Dorr Co., has been elected to succeed the retiring president, E. R. Ramsey. Hitch has been associated with the Dorr organization ever since completing his civil engineering studies at Harvard in 1927.

Willing Water rated a picture and feature story in the Atlanta, Ga., *Constitution* recently as the "precocious, phantom public relations professor of Atlanta's municipally owned utility, the water works department" who had to eat his words. "Atlanta grows where water goes" was Willie's favorite slogan. Then came the "Plan of Improvement," adding 82 sq miles of unwater-supplied area and 100,000 population to the city and all Willie could moan was "Atlanta sure growed where no water flowed." The story had a happy ending, however, for Willie and, through him, general manager Paul Weir are given full credit for not sulking but getting into immediate action with a five-year ten-million-dollar program to bring the slogan and the city back into harmony.

(Continued on page 44 P&R)

M-SCOPE Pipe Finder

LIGHTWEIGHT MODEL

Catalog No. 25K

On Request

JOSEPH G. POLLARD CO., Inc.

Pipe Line Equipment

New Hyde Park **New York**

REPLACE troublesome VALVES With . . .

EDDY MECHANICAL JOINT GATE VALVES

Since 1840 EDDY For Long Service

Old and troublesome valves . . . or too few valves in a distribution system . . . can be responsible for dangerous and costly slow-down or shut-down of water supply for every day use or, more serious, when badly needed in event of an emergency. Now is the time to make replacements and to install new valves where conditions show the need for so doing. The Eddy Valve, bronze mounted throughout, with mechanical joint connections (only a ratchet wrench needed) is best for easy installation . . . for easy operation . . . for long life trouble-free service.

Write today for prices and delivery date for valves needed to modernize your water distribution system.

EDDY

VALVE COMPANY

WATERFORD NEW YORK

A subsidiary of James B. Clow & Sons

(Continued from page 42 P&R)

Watching the Fords go by has not been the AWWA way at all. Ever since May 1908, in fact, the Association has been inviting them in, and in they have come—not as a fleet, but as a family. The Wabash Fords these are, not the Willow Run ones—the Ford Meter Box Fords, that is, not the Ford Motor promoters. It was Grandmother's and Grandfather's membership which established the Ford foundation in AWWA; Richard, John L., and Wilbur, of their four sons, built on it; and now John L. Jr and John H. of the third generation have been introduced as 1953 models, the former of Dallas, the latter soon to be located in North Carolina. Specifically because these Fords do not go by, we can hope that they too are in mass production.

Curse removal will have to be added to the already rugged routine of Oklahoma City water treatment if Supt. Morrison Cunningham is going to continue providing water that can be considered entirely safe, for the Indian sign recently put on, or in, the city's raw water supply is said to be completely resistant to conventional types of water treatment. What brought this ill fortune down upon our paleface prexy was the release of water from Canton Lake, 100 miles up the North Canadian River, to supplement the drought-dwindled supply in Oklahoma City's reservoirs, thereby "spoiling" the hunting and fishing grounds of the Cheyenne and Arapahoe Indians. Claiming violation of an old treaty that promised them free fishing and hunting "as long as water flowed and grass grew," Chief Bennie Spotted Wolf, in a colorful ceremony at the dam, broke a peace pipe and started the drums beating while Chief Henry Spotted Crow invoked a solemn curse upon the waters. The curse, of course, was said to be strictly a limited one, intended only "to keep fish from biting and ducks from landing on the surface of the Oklahoma City lakes," where it costs money to fish and hunt. But with the chiefs so rusty at hexification, we wouldn't be too sure they remember their own strength. Meanwhile, it will be Chief Morrison On-the-spot Cunningham.

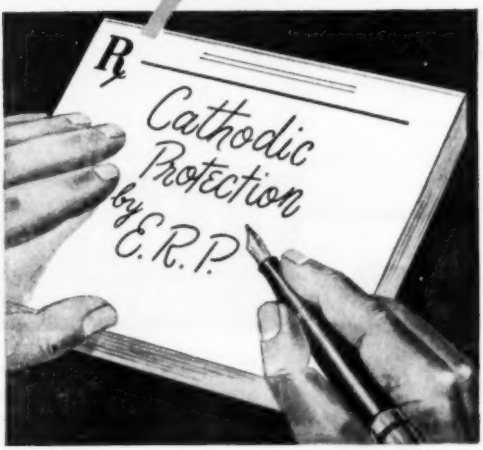
The midwestern sales office and service center of Builders-Providence, Inc., and the Omega Machine Co. has been moved from Wilmette, Ill., to 2039 W. Howard St., Chicago. Personnel of the office and the addresses of various local representatives are not affected by the move, which was made on July 15.

(Continued on page 46 P&R)

BOND-O
for
Uniformity
NORTHROP & COMPANY, INC.
SPRING VALLEY, N. Y.
Northrop
MACHINE BLENDED
SELF-CAULKING
JOINT COMPOUND
FOR
BELL & SPIGOT
CAST IRON
WATER PIPE

℞ FOR CORROSION...

You don't need a specialist to *recognize* Corrosion. But you do need one to treat it successfully. The skill required to achieve complete corrosion control comes only from the knowledge and experience gained through years of practical application.



Recognition of that fact is one reason more and more people are turning to E.R.P. for assistance on corrosion problems — one reason that thousands of buried or submerged steel structures of all types have been completely protected against corrosion by E.R.P. engineers. Corrosion specialists *for over 17 years,* these men are highly trained and well equipped to help you with *your* corrosion problem. Write for full information today.

COMPLETE CATHODIC PROTECTION SERVICE • DESIGN ENGINEERING MAINTENANCE INSTALLATION EQUIPMENT

ELECTRO RUST-PROOFING CORP. (N. J.)
BELLEVILLE 9, NEW JERSEY
REPRESENTED IN PRINCIPAL CITIES IN THE UNITED STATES

-E27

(Continued from page 44 P&R)

A 9,100-gal chorus is the quite obvious reason why "Dancing Waters" has become one of the most talked about shows in America as well as in Europe. Having played to a packed house night after night at New York's Radio City Music Hall last winter, the sensational vaudeville feature has since been to London for coronation week, to Toronto, Atlantic City, and Dallas, getting rave reviews everywhere. Basic difficulty of putting the show on the road to give everyone a look has been that of setting up the several thousand feet of steel pipe, 4,000 jets, and 19 electric motors which constitute its props. The cast? No problem at all. A new supply of chlorined chorines is available at every tap at a mere twist of the wrist. The dance, of course, is actuated and directed by the props and by colored lights, together requiring some 60,000 watts of power. All of which would suggest it as a natural for some water and light utility's public relations program were it not for the $250,000 cost of the German-made version now on tour. Of course, a little less elaborate and charged off to aeration . . .

Our "gal," if you haven't guessed, is your four quarts.

Remington Rand business machines and office equipment are now being offered on a purchase-or-lease basis that makes all the company's machines and equipment available for rental. Previously, only such special units as punched-card machines and microfilming cameras were available on a rent-or-purchase basis.

(Continued on page 48 P&R)

LIMITORQUE
VALVE CONTROLS

From coast to coast, hundreds of LimiTorque Controls are in service in water works and sewage disposal plants for automatic or push-button operation of valves up to 120 inch diameter. Why is acceptance so widespread? Because LimiTorque Operators are designed to provide dependable, safe and sure valve actuation at all times.

LimiTorque is self-contained and is applicable to all makes of valves. Any available power source may be used to actuate the operator: Electricity, water, air, oil, gas, etc.

A feature of LimiTorque is the torque limit switch which controls the closing thrust on the valve stem and prevents damage to valve operating parts.

Write for Catalog

PHILADELPHIA GEAR WORKS, Inc.
ERIE AVENUE and G STREET, PHILADELPHIA 34, PA.
New York • Pittsburgh • Chicago • Houston • Lynchburg, Va.

WORTHINGTON-GAMON

WATCH DOG

The meter used by thousands of municipalities in the U. S.

WATER METERS

"Watch Dog" models . . . made in standard capacities from 20 g.p.m. up: frost-proof and split case in household sizes. Disc, turbine, or compound type.

SURE TO MEET YOUR SPECIFICATIONS FOR ACCURACY, LOW MAINTENANCE, LONG LIFE.

Before you invest in water meters, get acquainted with the design and performance advantages which make Worthington-Gamon Watch Dog Water Meters first choice of so many municipalities and private water companies in the United States.

WORTHINGTON-GAMON METER DIVISION

Worthington Corporation

296 SOUTH STREET, NEWARK 5, NEW JERSEY

OFFICES IN ALL PRINCIPAL CITIES

(Continued from page 46 P&R)

"Certain as your water supply" is the way Novadel-Agene Corp. advertises the operations of its Flour Service Div., thereby coining what we have high hopes will become a cliché. "High hopes" not for any consequent increase in belief, but for the recognition that such hackneying is bound to bring. The razor of "sharp as," the nails of "hard as," the gold of "good as" are certainly no sharper, harder, nor better than water supply is certain. And although we might have expected that Wallace & Tiernan Co., Inc., agents for Novadel-Agene and, as such, coiners of the phrase, would instead have said "*safe* as your water supply," we'll certainly not argue the greater need of a substitute for "sure as shooting." On the other hand, unless the weather becomes right as rain quite soon, in the Northeast and in Texas, at least, the "safe" may be safer than "certain."

William G. Hamlin, sanitary engineer and formerly waste-disposal engineer for Procter & Gamble Co., has joined the staff of the Ohio River Valley Water Sanitation Com. According to executive director Edward J. Cleary, the Commission has about completed its hearings and requirements for municipal sewage treatment, and now plans to concentrate on control of industrial wastes.

Havens and Emerson, consulting engineers of Cleveland and New York, have moved their Cleveland office to No. 640 in the Leader Bldg.

(Continued on page 50 P&R)

WHY USE JOHNSON WELL SCREENS?

1. **Less drawdown.**
2. **Greater specific capacity.**
3. **Lowest pumping cost per million gallons of water.**

True economy is measured not by first cost alone, but in lowest yearly cost. The JOHNSON WELL SCREEN combines an unmatched record of experience and dependability with greatest strength and durability. It is the finest and most truly economical well screen in the world.

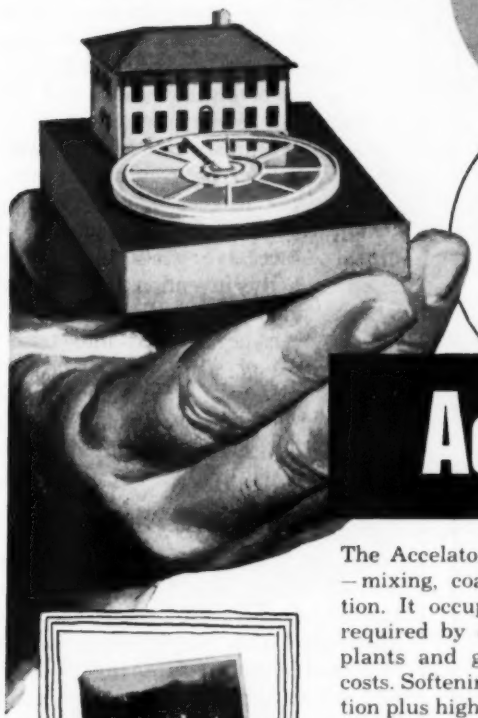
EDWARD E. JOHNSON, INC.

~ well screen specialists since 1904 ~

St. Paul 14, Minn.

proven high-rate water treatment in

less space at lower cost



Accelator®

The Accelator combines – in a single unit – mixing, coagulation and solids separation. It occupies a fraction of the space required by old style, slow-rate treating plants and greatly reduces installation costs. Softening, clarification and stabilization plus highly efficient algae and bacteria removal are obtained at the highest flow rates because of the Accelator slurry recirculation and dynamic separation. For full details send for your copy of the informative 28-page Accelator bulletin.

Use coupon below.

INFILCO

INFILCO INC., P. O. Box 5033
Tucson, Arizona

Please send to my attention _____ copies of Accelator Bulletin 1825-J.

Name_____

Title_____

Firm_____

Address_____

City_____ State_____

The Quest for Pure Water

in 1450 B. C.

(as pictured on the wall of the tomb of Amenophis II at Thebes)

Not so much what happened in the 550 years before this, but what has followed to bring water works practice to its present state of development is the story told in authoritative detail by M. N. Baker in his history of water purification from the earliest records to the 1940's.

466 Text Pages
73 Illustrations
900 References

List price **$5.00**

Special price to members who send cash with order **$4.00**

Order from

American Water Works Association

521 Fifth Avenue New York 17, N. Y.

(Continued from page 48 P&R)

The castle that a man's home is, has long been invaded by the minions of the marketplace, but now even the throne room has fallen. Not many months ago when the teleflush index offered definite water-pressure proof that the home audience was managing to escape the din, discord, and disingenuousness of invasive radio and TV commercials, advertisers began to wrack their brains. Not satisfied with longer or louder or even sneak spiels to entrap the listener or viewer, they sought a means of following him right into his sanctuary. And now they've found it in the invention of a special cutting blade by which advertising and publicity can be inserted into transparent cakes of soap. We, who can shut our eyes, though, will not say die until the throne itself makes like a music box to give us singing commercials with each sitting.

Charles V. Joyce Sr., division engineer for the Washington Suburban Sanitary Dist., has been awarded the Samuel A. Greeley Award of the American Public Works Assn. for his "long and faithful service" to the utility, with which he has been connected since 1919, the year after it was founded. The presentation was made at the association's Public Works Congress in New Orleans on October 29.

Worthington-Gamon Meter Div. sales representatives just appointed include Sidney S. Small and William L. Tucker for the Los Angeles district, and Roy A. Saylors for the Denver and Salt Lake City districts. The two Los Angeles representatives have had previous experience with Worthington-Gamon; Saylors has been meter superintendent of the Lincoln, Neb., Water Dept.

FORD

MONITOR COVERS

FIT 24", 30", AND 36"

METER PIT BARRELS

WRITE FOR CATALOG

Ford Catalog No. 50 contains full information. Send for your copy today. FREE.

For covering large meter pits the Monitor Cover is most useful. With lid opening large enough to permit meter reader to enter setting, this cover is used over pits containing 1½" or 2" meters, or multiple settings of smaller meters. An inner lid is available if extra frost protection is desired.

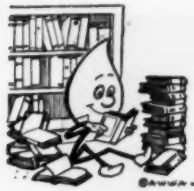
The cover is equipped with the Ford Lifter Worm Lock that opens lid easily, even when frozen.

FOR BETTER WATER SERVICES

FORD

Manufactured by THE FORD METER BOX COMPANY, INC.

Wabash, Indiana



The Reading Meter

Water and Politics: *A Study of Water Policies and Administration in the Development of Los Angeles. Vincent Ostrom. The Haynes Foundation, 607 S. Hill St., Los Angeles 14, Calif. (1953) 297 pp.; $4.00 clothbound, $3.50 paperbound*

Originally prepared as a thesis submitted for a Ph.D. in political science at UCLA, the text was later revised and brought up to date by the author.

Perhaps the most valuable part of the text is the outline of the community ownership of water rights as they developed from the Spanish grant to *El Pueblo de Nuestra Senora la Reina de Los Angeles.* The communal water system of the pueblo grew into the Dept. of Water and Power along natural lines. Rivalry between the municipal group and private interests in water works and especially power supply resulted in many political battles. It is the story of these conflicts of interest—together with the way in which water problems influenced the development and even creation of political institutions—that makes up most of the book.

The Owens River development as recounted here lacks the dramatic quality of Nadeau's *The Water Seekers* (see December 1950 "Reading Meter," p. 62 P&R), but it merits study.

The conflict of interest among the states over Colorado River water is described in the account of the development of the Southern California Metropolitan Water Dist. supply.

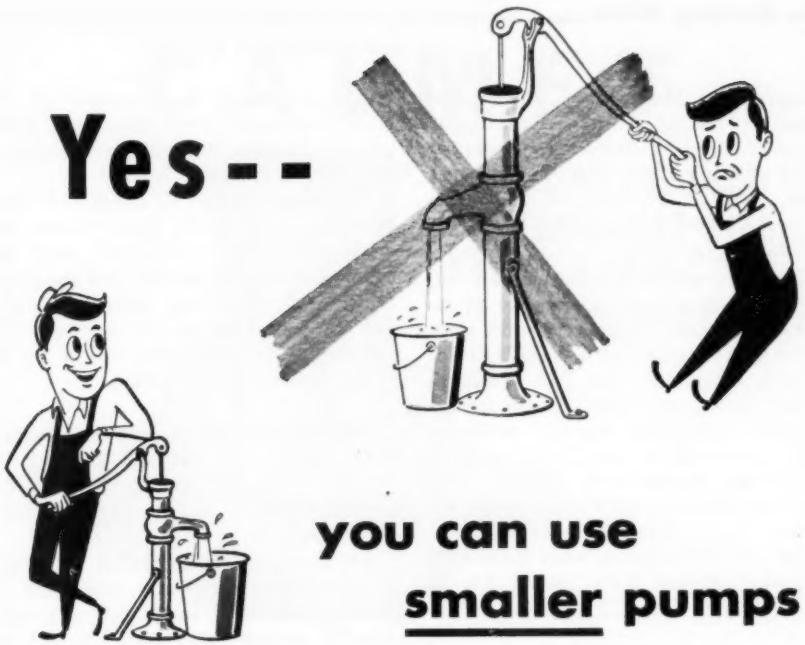
Appropriate tribute is paid to Samuel B. Morris, past-president of AWWA and presently general manager of the Dept. of Water and Power. The author's accuracy becomes subject to question, however, when we note that the name of another AWWA past-president—W. W. Hurlbut—is given an extra "t," while that of the late Ray Goudey, sanitary engineer of the water department, loses the "e." One hopes that the author's lack of accuracy in spelling does not extend to the important items of Los Angeles history.

A Standard Classification of Municipal Accounts. *National Committee on Governmental Accounting (1953) 129 pp.; $3.00 from Municipal Finance Officers Assn., 1313 E. 60th St., Chicago 37, Ill.*

This work constitutes a revision of the 1939 publication entitled *A Standard Classification of Municipal Revenues and Expenditures,* and differs from its predecessor primarily in the enlargement of its scope. In addition to revenue and expenditure accounts, contained in the 1939 standard, the new work includes balance sheet accounts, with explanations. In addition, an appendix offers classification of accounts for Canadian municipalities, with notes on variations and similarities between the U.S. and Canadian systems. The book is designed to be used in conjunction with another book by the Committee—*Municipal Accounting and Auditing.* In Canada, the proper companion book is the Dominion Bureau of Statistics' *Manual of Instructions* for financial statements and other matters. The explanations provided with the accounts should be helpful, and they appear to vary in length in accordance with the complexity of the classification principle being explained.

(*Continued on page 54 P&R*)

Yes--



you can use smaller pumps

...when you protect pipe lines with BITUMASTIC® 70-B ENAMEL

PIPE LINES don't "shrink" when interior surfaces are lined with Bitumastic 70-B Enamel . . . because this durable enamel prevents rust, corrosion, incrustation and tuberculation. With an inside diameter that *stays* the same, line capacity doesn't decrease. So there's no need, even after decades of service, to replace pumps with bigger ones that cost more to buy and operate.

By using Bitumastic 70-B Enamel, you also save on the initial cost of steel pipe. You don't waste money by buying *over-sized* pipe in order to allow for future "shrinkage." You specify pipe solely on the basis of desired capacity.

Bitumastic 70-B Enamel — when applied to a thickness of 3/32"—protects the *exterior* of pipe against the corrosive action of soil. It is wasteful to specify an excess of wall thickness to compensate for corrosion. It is more economical to specify just enough wall thickness to give the pipe adequate structural strength and to use Bitumastic 70-B Enamel to prevent corrosion.

For your large-diameter water lines specify strong, durable steel pipe, lined and coated with Bitumastic 70-B Enamel. Your community will get worthwhile savings. Write to us for complete information.

KOPPERS BITUMASTIC ENAMELS

KOPPERS COMPANY, INC.

Tar Products Division, Dept. 1005-T, Pittsburgh 19, Pennsylvania

DISTRICT OFFICES: BOSTON, CHICAGO, LOS ANGELES, NEW YORK, PITTSBURGH, AND WOODWARD, ALA.

The Reading Meter

(Continued from page 52 P&R)

Arid Zone Hydrology: *Reviews of research. United Nations Educational, Scientific, and Cultural Organization (UNESCO), Paris (1953) 212 pp.; maps; $5 from International Documents Service, Columbia University Press, 2960 Broadway, New York 27, N.Y.*

The eight reports contained in this volume were submitted in response to an invitation extended to experts in the eight arid regions into which UNESCO's Interim International Arid Zone Research Council divided the world. These regions comprise northwest Africa, northeast Africa, south Africa (the Union of South Africa and Angola), the Middle East, India and Pakistan, the United States and Canada, Latin America, and Australia. There is no discussion of what the study's mapmaker, Peveril Meigs, referred to as "the vast deserts and steppes of the USSR, Chinese Turkestan, and Mongolia." Possibly it rained—in Moscow—the day the invitation arrived.

The report by Ray K. Linsley of Stanford University on the United States and Canada is largely concerned with the techniques of measurement and the possibilities of extending available water sources. A bibliography of over 400 references occupies nearly half of the 24 pages devoted to this region.

The Use of Water in Pennsylvania, 1951. *John W. Mangan & Jack B. Graham. Circular 257, Geological Survey, Washington 25, D.C. (1953) 11 pp.; paperbound; free*

An average annual rainfall of 42 in., giving Pennsylvania the equivalent of 90.2 bgd to draw upon, leaves a comfortable margin for growth, waste, and loss above the 10.7 bgd that the Commonwealth is now using. Public water supplies account for a mere 1.3 bgd of this total, and serve a full third of their share to industry. Private industrial supplies account for more than 90 per cent of the water withdrawn, thus far overshadowing the more important municipal withdrawals.

Pipefitters Handbook. *Forrest R. Lindsey. The Industrial Press, 148 Lafayette St., New York 13, N.Y. (1953) 282 pp.; $6*

The emphasis is upon practicality in this book, which is intended as an addition to the pipefitter's working tools rather than to the office bookshelf. Extensive tables provide such information as the laying length of nipples, reducers, and other fittings; the clearance to allow when installing threaded fittings near a wall or other obstruction, the proper spacing for drilling equidistant bolt holes in flanges, and so on.

(Continued on page 68 P&R)

Are you

MOVING

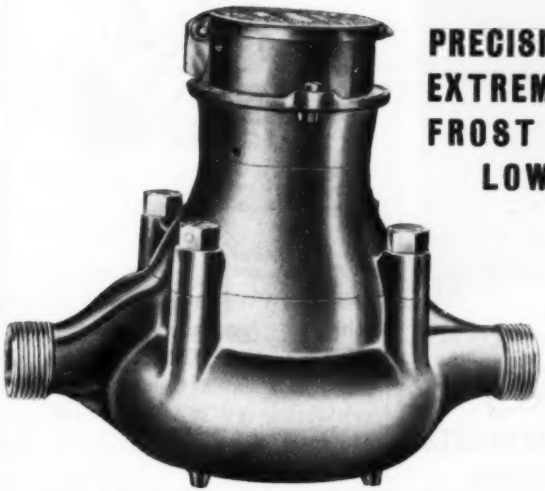
?

Please advise AWWA promptly of any change in your mailing address. Leaving a forwarding address at your old post office is not enough, because postal regulations require periodicals to be returned to the sender if not claimed at the original destination. And, to help us identify you properly, please include your old as well as your new address when writing.

Prompt notification will keep your Journals and other communications coming to you without annoying delays and lapses.

American Water Works Assn., Inc.
521 Fifth Ave. New York 17, N.Y.

CALMET



PRECISION ACCURACY
EXTREME LONG LIFE
FROST PROTECTED
LOW UPKEEP

WILL MEASURE UP TO YOUR REQUIREMENTS

PRECISION ACCURACY—CALMET's oscillating piston is semi-floating, precision balanced. A super-sensitive meter that measures with unfailing accuracy the various flows to the smallest drip.

EXTREME LONG LIFE—CALMET's slower moving piston and gear train ratio of 256-to-1 assures long life, less wear on precision parts. Simple design assures years of service with a minimum of attention.

LOW UPKEEP—CALMETS are easy to take apart, easy to repair for low upkeep. The split case design with spuds in the base permits quick removal of working parts for cleaning or inspection without breaking the line connection.

FROST PROTECTED—Exclusive FROST-PROOF BOLTS provide maximum protection against damage from freezing or excessive pressure, by allowing the main case and the measuring chamber to separate. The meter can then be serviced at the cost of only a few cents for shear pins.

● ***SALES REPRESENTATIVES—Write for complete details of the CALMET franchise in your territory.***

CALMET WATER METERS

MADE BY WELL MACHINERY & SUPPLY CO., INC.—FORT WORTH, TEXAS

APPROVED
by UNDERWRITERS' LABORATORIES, Inc.

GREENBERG
Independently Valved HYDRANTS
for non-freezing climates

Western water works engineers and fire chiefs were the first to approve Greenberg California-type fire hydrants. Now, after exhaustive tests, Underwriters' Laboratories, Inc. has confirmed your judgment.

Greenberg No. 74 and 76 hydrants are equipped with independent valves of a new type which open quickly and easily, allowing full flow with minimum resistance. They close tightly without water hammer. A major improvement over the old "cork in bottle" type valve!

Other innovations such as you would expect of the people who evolved the California-type hydrant 75 years ago are shown in the free booklet "Hydrants by Greenberg." May we send you a copy?

STABILITY since 1854

BRONZE PRODUCTS
GREENBERG

M. GREENBERG'S SONS
765 Folsom St. • San Francisco, Calif. • Exbrook 2-3143
Los Angeles • Phoenix • Seattle • Portland • Spokane,
Salt Lake City • Denver • Kansas City • Dallas • Houston
New Orleans • Honolulu • New York • Washington, D. C.

Correspondence

Stamps

To the Editor:

The AWWA is in danger of merging with the American Philatelic Society, what with E. L. Filby asking the government to issue a commemorative stamp celebrating AWWA's 75th birthday, Bill Hurst at Winnipeg aiding and abetting him, and such other AWWAers as Sid Wilson being avid collectors. Even when W. S. and son Jim Mahlie, of the Fort Worth, Tex., filtration plant, made a fluoridation raid on us at Brantford, the talk finally turned to stamps, all three of us being collectors. Later Mrs. Mahlie pointed out that much of Jim's pleasure from stamps comes from keeping a little polio victim down the street supplied with any duplicates—so now a packet has gone from the North to the South for the little fellow who doesn't get around as well as we do.

How about it, you AWWA stampophiles, can we get more packets—from North, South, East, and West? They should arrive just in time for Christmas. Send them, with a brief note "to the little fellow down the street," to W. S. Mahlie, Apt. 60, 3900 White Settlement Rd., Fort Worth, Tex. While we're asking Uncle Sam for a stamp, let's do a little giving.

DON WILLIAMS
Water Works Lab.
Brantford, Ont.; Oct. 1, 1953

Professional Services

ALBRIGHT & FRIEL, INC.

Consulting Engineers

Water, Sewage and Industrial Waste Problems
Airfields, Refuse Incinerators, Power Plants
Industrial Buildings
City Planning Reports Valuations
Laboratory

121 S. Broad St. Philadelphia 7, Pa.

ALVORD, BURDICK & HOWSON

Engineers

Water Works, Water Purification, Flood Relief, Sewerage Disposal
Drainage, Appraisals, Power Generation

20 North Wacker Drive Chicago 6

AYRES, LEWIS, NORRIS & MAY

Consulting Engineers

Louis E. Ayres Robert Norris
George E. Lewis Donald C. May
Stuart B. Maynard Homer J. Hayward

Waterworks, Sewerage, Electric Power

500 Wolverine Building, Ann Arbor, Michigan

CARL A. BAYS & ASSOCIATES, INC.

Geologists—Engineers—Geophysicists
Industrial Consultants

Office and Laboratory—308 N. Orchard St.
Mail Address—P.O. Box 189
Urbana, Illinois

A. S. BEHRMAN

Chemical Consultant

Water Treatment
Ion Exchange Processes and Materials
Patents

9 S. Clinton St. Chicago 6, Ill.

BLACK & VEATCH

Consulting Engineers

4706 Broadway, Kansas City 2, Mo.

Water Supply Purification and Distribution; Electric Lighting and Power Generation, Transmission and Distribution; Sewerage and Sewage Disposal; Valuations, Special Investigations and Reports

BLACK LABORATORIES, INC.

Consulting Engineers and Chemists

on all problems of
Water, Sewage and Waste Treatment
ANALYSIS—TREATMENT—CONTROL—RESEARCH

700 S. E. 3rd St. Gainesville, Fla.

CLINTON L. BOGERT ASSOCIATES

Consulting Engineers

Clinton L. Bogert Ivan L. Bogert
Donald M. Ditmars Robert A. Lincoln

Water and Sewage Works
Refuse Disposal Industrial Wastes
Drainage Flood Control

624 Madison Avenue New York 22, N. Y.

Bowe, Albertson & Associates

Engineers

Water and Sewage Works
Industrial Wastes—Refuse Disposal—Municipal Projects
Airfields—Industrial Buildings
Reports—Designs—Estimates
Valuations—Laboratory Service

110 William St. New York 38, N.Y.

BUCK, SEIFERT AND JOST

Consulting Engineers
(Formerly Nicholas S. Hill Associates)

Water Supply—Sewage Disposal—Hydraulic Developments

Reports, Investigations, Valuations, Rates, Design, Construction, Operation, Management, Chemical and Biological Laboratories

112 E. 19th St., New York 3, N. Y.

BURGESS & NIPLE

Consulting Engineers

(Established 1908)

Water supply, treatment and distribution
Sewage and industrial wastes disposal
Investigations, reports, appraisals, rates
Airports Municipal Engineering Supervision

584 E. Broad St. Columbus 15, Ohio

Cotton, Pierce, Streander, Inc.

Associated Consulting Engineers

E. R. Cotton E. M. Pierce
P. B. Streander G. A. Gieseke
I. J. Silverstone

Water Supply, Water Purification
Sewerage, Sewage Treatment
Refuse Disposal

P. O. Box 198 Hyde Park 36, Mass. 132 Nassau Street New York 38, N.Y.

BURNS & McDONNELL

Consulting and Designing Engineers

Water Works, Light and Power, Sewerage,
Reports, Designs, Appraisals, Rate
Investigations.

Kansas City 2, Mo. P.O. Box 7088 Cleveland 14, Ohio 1404 E. 9th St.

DE LEUW, CATHER & COMPANY

Water Supply Sewerage
Railroads Highways

Grade Separations—Bridges—Subways
Local Transportation

Investigations—Reports—Appraisals
Plans and Supervision of Construction

150 N. Wacker Drive Chicago 6 79 McAllister St. San Francisco 2

JAMES M. CAIRD

Established 1898

C. E. Clifton, H. A. Bennett

Chemist and Bacteriologist

WATER ANALYSIS
TESTS OF FILTER PLANTS

Cannon Bldg. Troy, N. Y.

FAY, SPOFFORD & THORNDIKE

Engineers

Charles M. Spofford Ralph W. Horne
John Ayer William L. Hyland
Bion A. Bowman Frank L. Lincoln
Carroll A. Farwell Howard J. Williams

Water Supply and Distribution—Drainage—Sewerage and Sewage Treatment—Airports—Bridges—Turnpikes

Investigations Reports Designs Valuations
Supervision of Construction

Boston New York

CAMP, DRESSER & McKEE

Consulting Engineers

Water Works, Water Treatment,
Sewerage and Wastes Disposal,
Flood Control

Investigations, Reports, Design
Supervision, Research, Development

6 Beacon St. Boston 8, Mass.

FINKBEINER, PETTIS & STROUT

Carleton S. Finkbeiner Charles E. Pettis
Harold K. Strout

Consulting Engineers

Reports, Designs, Supervision,
Water Supply, Water Treatment, Sewerage,
Sewage Treatment, Wastes Treatment,
Valuations & Appraisals

518 Jefferson Avenue Toledo 4, Ohio

THE CHESTER ENGINEERS

Water Supply and Purification
Sewage and Industrial Waste Treatment
Power Plants—Incineration—Gas Systems
Valuations—Rates—Management
Laboratory—City Planning

210 E. Park Way
Pittsburgh 12, Penna.

FREESE, NICHOLS AND TURNER

Consulting Engineers

2111 C and I Life Bldg.
Houston 2, Texas

CH-1624

CONSOER, TOWNSEND & ASSOCIATES

Water Supply—Sewerage
Flood Control & Drainage—Bridges
Ornamental Street Lighting—Paving
Light & Power Plants—Appraisals

351 E. Ohio St. Chicago 11

FULBRIGHT LABORATORIES, Inc.

Consultants

Chemists and Chemical Engineers

Industrial Water and Waste
Surveys

Tel. 5-5726

Box 1284 Charlotte, N. C.

GANNETT FLEMING CORDDRY & CARPENTER, Inc.

Engineers

Water Works—Sewerage
Industrial Wastes—Garbage Disposal
Roads—Airports—Bridges—Flood Control
Town Planning—Appraisals
Investigations & Reports

Harrisburg, Pa. **Philadelphia, Pa.**
Pittsburgh, Pa. **Daytona Beach, Fla.**

GILBERT ASSOCIATES, INC.

Engineers • Consultants • Constructors

Water Supply and Purification
Sewage and Industrial Waste Treatment
Chemical Laboratory Service
Investigations and Reports

Reading, Pa.

New York **Philadelphia**
Washington **Staunton, Va.**

GLACE & GLACE

Consulting Sanitary Engineers

Sewerage and Sewage Treatment
Water Supply and Purification
Industrial Wastes Disposal

Design, Construction, and
Supervision of Operation

1001 North Front St., Harrisburg, Pa.

GREELEY AND HANSEN

Engineers

Water Supply, Water Purification
Sewerage, Sewage Treatment
Refuse Disposal

220 S. State Street, Chicago 4

WILLIAM F. GUYTON

Consulting Ground-Water Hydrologist

Underground Water Supplies

Investigations, Reports, Advice

307 W. 12th St. **Austin 1, Texas**
Tel. 7-7165

HAVENS & EMERSON

W. L. Havens C. A. Emerson
A. A. Burger F. C. Tolles F. W. Jones
W. L. Leach H. H. Moseley J. W. Avery

Consulting Engineers

Water, Sewage, Garbage, Industrial
Wastes, Valuations—Laboratories

Leader Bldg. **Woolworth Bldg.**
CLEVELAND 14 **NEW YORK 7**

HAZEN AND SAWYER

Engineers

Richard Hazen Alfred W. Sawyer

Municipal and Industrial Water Supply
Purification and Distribution
Sewage Works and Waste Disposal

Investigations, Design,
Supervision of Construction and Operations

110 East 42nd Street **New York 17, N.Y.**

HORNER & SHIFRIN

Consulting Engineers

W. W. Horner V. C. Lischer
H. Shifrin E. E. Bloss

Water Supply—Airports—Hydraulic Engineering—Sewerage—Sewage Treatment—Municipal Engineering—Reports

Shell Building **St. Louis 3, Mo.**

ROBERT W. HUNT CO.

Inspection Engineers

(Established 1888)

Inspection and Test at Point
of Origin of Pumps, Tanks,
Conduit, Pipe and Accessories

175 W. Jackson Blvd.
Chicago 4, Ill.
and Principal Mfg. Centers

THE JENNINGS-LAWRENCE CO.

Civil & Municipal Engineers
Consultants

Water Supply, Treatment & Distribution
Sewers & Sewage Treatment
Reports—Design—Construction

1392 King Avenue **Columbus 12, Ohio**

ROBERT M. JOHNSTON AND ASSOCIATES

Consulting Chemists—Bacteriologists

Analyses—Water, Sewage, Industrial Waste
Research Litigations

915-17 N. Second St. **Harrisburg, Pa.**

JONES, HENRY & WILLIAMS

Consulting Sanitary Engineers

Water Works
Sewerage & Treatment
Waste Disposal

Security Bldg. **Toledo 4, Ohio**

MORRIS KNOWLES INC.

Engineers

Water Supply and Purification,
Sewerage and Sewage Disposal,
Industrial Wastes, Valuations,
Laboratory, City Planning

Park Building **Pittsburgh 22, Pa.**

PARSONS, BRINCKERHOFF, HALL & MACDONALD

G. Gale Dixon, Associate

Civil and Sanitary Engineers

Water, Sewage, Drainage and
Industrial Waste Problems.

Structures — Power — Transportation

51 Broadway **New York 6, N. Y.**

LEGGETTE & BRASHEARS

Consulting Ground Water Geologists

Water Supply — Salt Water Problems
Dewatering — Investigations
Recharging — Reports

551 Fifth Avenue **New York 17, N. Y.**

MALCOLM PIRNIE ENGINEERS

Civil & Sanitary Engineers

MALCOLM PIRNIE — ERNEST W. WHITLOCK
ROBERT D. MITCHELL — CARL A. ARENANDER
MALCOLM PIRNIE, JR.

Investigations, Reports, Plans
Supervision of Construction and Operations
Appraisals and Rates

25 W. 43rd St. **New York 36, N. Y.**

METCALF & EDDY

Engineers

Water, Sewage, Drainage, Refuse
and Industrial Wastes Problems
Airfields — Valuations
Laboratory

Statler Building
Boston 16

THE PITOMETER COMPANY

Engineers

Water Waste Surveys
Trunk Main Surveys
Water Distribution Studies
Water Measurement & Special
Hydraulic Investigations

50 Church Street **New York**

NUSSBAUMER, CLARKE & VELZY

Consulting Engineers

NEWELL L. NUSSBAUMER — IRVING CLARKE
CHARLES R. VELZY — RAYMOND H. MURRAY

Water Supply and Treatment
Sewage and Industrial Waste Treatment
Garbage Incineration
Appraisals and Rate Studies

327 Franklin Street **Buffalo 2, N.Y.**
500 Fifth Avenue **New York 36, N.Y.**

LEE T. PURCELL

Consulting Engineer

Water Supply & Purification; Sewerage & Sewage Disposal; Industrial Wastes; Investigations & Reports; Design; Supervision of Construction & Operation

Analytical Laboratories

36 De Grasse St. **Paterson 1, N. J.**

THE H. C. NUTTING COMPANY

Engineers

WATER WASTE SURVEYS
Water Distribution Studies
Trunk Main Surveys
Meter and Fire Flow Test

4120 Airport Road **Cincinnati 26, Ohio**

THOMAS M. RIDDICK

Consulting Engineer and Chemist

Municipal and Industrial Water Purification,
Sewage Treatment, Plant Supervision,
Industrial Waste Treatment,
Laboratories for Chemical and Bacteriological Analyses

369 E. 149th St. **New York 55, N.Y.**
MOtt Haven 5-2424

PACIFIC ENGINEERING LABORATORY

Chemical and Biological Laboratory
Analyses and Investigations

604 Mission St. **San Francisco 5**

RIPPLE & HOWE

Consulting Engineers

O. J. RIPPLE — B. V. HOWE

Appraisals—Reports
Design—Supervision

Water Works Systems, Filtration and Softening Plants, Reservoirs, and Dams, Sanitary and Storm Sewers, Sewage Treatment Plants, Refuse Disposal, Airports

833-35—23rd St., Denver 5, Colo.

NICHOLAS A. ROSE

Consulting Ground Water Geologist

Investigations
Reports
Advisory Service

1010 Dennis Ave. Houston 2, Tex.

STANLEY ENGINEERING COMPANY

Waterworks—Sewerage
Drainage—Flood Control
Airports—Electric Power

Hershey Building
Muscatine, Ia.

RUSSELL & AXON

Consulting Engineers

Civil—Sanitary—Structural
Industrial—Electrical
Rate Investigations

408 Olive St., St. Louis 2, Mo.
Municipal Airport, Daytona Beach, Fla.

ALDEN E. STILSON & ASSOCIATES

(Limited)
Consulting Engineers

Water Supply—Sewerage—Waste Disposal
Bridges—Highways—Industrial Buildings
Studies—Surveys—Reports

209 S. High St. Columbus, Ohio

EDWARD J. SCHAEFER

Consulting Ground-Water Hydrologist

Investigations, Reports, Advice
on
Underground Water-Supply Problems

607 Glenmont Ave. Telephone
Columbus 14, Ohio Ludlow 3316

J. STEPHEN WATKINS

J. S. Watkins G. R. Watkins
Consulting Engineers

Municipal and Industrial Engineering, Water Supply and Purification, Sewerage and Sewage Treatment, Highways and Structures, Reports, Investigations and Rate Structures.

251 East High Street Lexington, Kentucky
Branch Office
901 Hoffman Building Louisville, Kentucky

MILES O. SHERRILL

Consulting Engineers
Marion C. Welch, Associate Engineer

Water Purification & Distribution—Sewerage & Sewage Disposal—Dams, Reservoirs & Area Drainage—Valuations & Reports—Oil & Industrial Wastes—Garbage Incineration—Swimming Pools

Frank S. Whitney Principal Engineer
Tri-State Airport Huntington, W. Va.
"THE SHERRILL ENGINEERS"

1412 Bardstown Road Louisville 4, Ky.

WESTON & SAMPSON

Consulting Engineers

Water Supply and Purification; Sewerage, Sewage and Industrial Waste Treatment. Reports, Designs, Supervision of Construction and Operation; Valuations.
Chemical and Bacteriological Analyses

14 Beacon Street Boston 8, Mass.

J. E. SIRRINE COMPANY

Engineers

Water Supply & Purification,
Sewage & Industrial Waste Disposal,
Stream Pollution Reports,
Utilities, Analyses

Greenville South Carolina

WHITMAN & HOWARD

Engineers
(Est. 1869.)

Investigations, Designs, Estimates, Reports and Supervision, Valuations, etc., in all Water Works and Sewerage Problems

89 Broad St. Boston, Mass.

SMITH AND GILLESPIE

Consulting Engineers

Water Supply and Treatment Plants; Sewerage, Sewage Treatment; Utilities; Zoning; Reports, Designs, Supervision of Construction and Operation; Appraisals.

P.O. Box 1048 Jacksonville, Fla.

WHITMAN, REQUARDT & ASSOCIATES

Engineers *Consultants*

Civil—Sanitary—Structural
Mechanical—Electrical
Reports, Plans,
Supervision, Appraisals

1304 St. Paul St. Baltimore 2, Md.

Condensation

Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

ANNUAL REPORTS

Community: **Santa Cruz, Calif.**
Reporting organization: Water Dept.
Year ending: June 30, '52
No. of employees: 36
Source of supply: surface and ground water
Type of treatment: filtration
Water produced (mil gal): 1,753
Water sold (mil gal): 1,507
Consumption (mil gal): resid.: 987.4; indus.: 300.6; irrigation: 134.4; coml.: 85.5
Water unaccounted for (%): 17.5
Metered services (%): 100
Revenue ($): water: 338,672; other: 2,446; total: 341,118
Expense ($): op. and maint.: 94,016; depn.: 68,356; other: 67,506; total: 229,878
Tax paid (% of revenue): 0.2
Income ($): 111,240
Bond interest ($): 15,006
Bond retirement ($): 37,500
Paid to general fund ($): 15,000
Debt outstanding ($): 625,000
Unit costs ($/mil gal): water: 9.05; power: 11.39; transmission and distr.: 19.13; admin. and general: 10.00
Treated water analysis: 158 samples for bact. analysis with 790 tubes tested showed 3.6% of tubes positive and 2.5% of samples with 3 or more tubes positive as annual avg; in any one month, varied from 0 to 18.2% tubes positive and 0 to 18.9% of samples with 3 or more tubes positive.

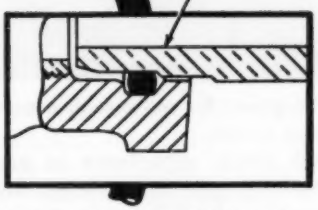
Community: **Detroit, Mich.**
Reporting organization: Board of Water Commissioners
Year ending: June 30, '52
Population served: 2,680,000 (area served: 294 sq mi)
Customers: 585,707
No. of employees: 626
Source of supply: Detroit R.
Type of treatment: coagulation, filtration
Water produced (mil gal): 145,192
Water sold (mil gal): 125,449
Water unaccounted for (%): 13.6
Consumption (mgd): max.: 665; avg: 397 (150 gpcd)
Metered services (%): 99+
Mains (mi): distr. and trans.: 5,619
Hydrants: 30,381 (Detroit only)
Distr. storage (mil gal): 125 (filtered-water), 8.0 (elevated)
Revenue ($): water: 14,363,127; other: 990,427; total: 15,353,554
Expense ($): op. and maint.: 6,286,879; depn.: 3,023,740; total: 9,310,619
Tax paid (% of revenue): none
Income ($): 6,042,935
Bond interest ($): 2,199,692
Added to reserve ($): 1,767,359
Net cost of works to date ($): 158,662,984
Debt outstanding ($): 58,064,000
Unit costs ($/mil gal): water: 2.84; power: 10.11; pumping and purif.: 19.27; trans. and distr.: 10.23; admin. and general: 7.32; total op. and maint.: 43.30
Treated water analysis (ppm): total solids: 125; total hardness: 97; total alky.: 74; pH: 7.5; temp. (°F): 50; plankton count: 400 (raw water), 78 (applied to filters); threshold odor number (plant effluent): 1; MPN (raw water, monthly avg): min.: 3; max.: 290; MPN (treated water): 0
Rates: (¢/1,000 cu ft): inside city: 62–92 plus monthly service charge based on meter size; outside city: 65–97 plus monthly service charge based on meter size
Other items: filter run (hr): avg.: 25; range: 19–31; max. hourly pumpage (mgd): 1,075.

Community: **St. Louis, Mo.**
Reporting organization: Water Div.
Year ending: Apr. 7, '52
Population served: 865,600
Customers: 162,290
Source of supply: Mississippi and Missouri rivers
Type of treatment: Presedimentation, softening, coagulation, filtration

(*Continued on page 64*)

WITH

NEW RING-TITE JOINT.....



Smith A.W.W.A. Specifications Gate Valves (4" through 12") and Smith Fire Hydrants (with 4" and 6" connecting joints) are now available with Ring-Tite joints for direct connection to Johns-Manville Class 150 Transite Ring-Tite Pipe. No special fittings or extra joint material needed. Installation is quick, easy, economical, and joints can be made in any weather and in roughest terrain. Tight, flexible joints are assured. At low pressures, radial compression of rubber rings seals the joint; increasing pressure wedges the rings—the higher the pressure the tighter the seal. For complete details write for Bulletin RT 53.

44

FIRE HYDRANTS · VALVES · SINCE 1896

THE A.P. SMITH MFG. CO.

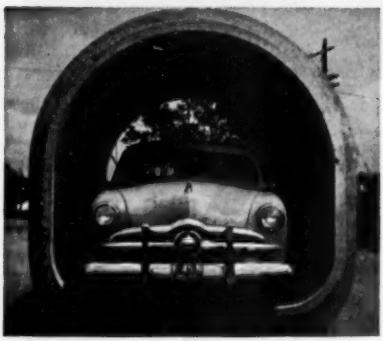
EAST ORANGE, NEW JERSEY

If it's concrete . . .

UNIVERSAL

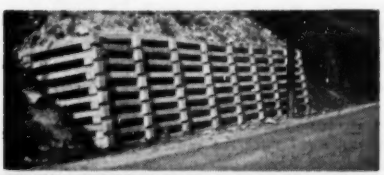
world's largest manufacturer of concrete sewer and culvert pipe

can make it



26 plants for convenient, economical service.

30 years' experience in pipe, cribbing, precast manholes, river-weights, flat base pipe. Name it, we make it!



UNIVERSAL
CONCRETE PIPE CO.
297 South High Street
Columbus, Ohio
Publishers of Famous "Pipe Dreams"

(*Continued from page 62*)

Water produced (mil gal) : 59,300
Consumption (mgd) : max.: 213; avg: 162 (187 gpcd)
Metered services (%) : 10.32 (metered consumption, 50% of total)
Mains (mi) : distr. and trans.: 1,281
Valves: 21,063
Hydrants: 15,155
Revenue ($) : water: 4,708,831; other: 193,378; total: 4,902,209
Expense ($) : op. and maint.: 4,195,502; other: 144,465; total: 4,340,067
Free service value ($) : 875,000
Income ($) : 380,279
Paid to general fund ($) : 130,232
Unit costs ($/mil gal) : chemicals: 10.20; total purif.: 16.28
Raw water analysis (ppm) : turbidity: 1,265; hardness: 189; color: 17; *Esch. coli* (per 100 ml) : 13,800
Treated water analysis (ppm) : turbidity: 0.11; hardness: 97; color: 7; *Esch. coli* (per 100 ml) : 0.0.

Community: **Mount Vernon, N.Y.**
Reporting organization: Board of Water Supply
Year ending: Dec. 31, '52
Population served: 71,899
Customers: 9,798
Source of supply: purchased
Water produced (mil gal) : 2,288
Water sold (mil gal) : 1,991
Water unaccounted for (%) : 13.0
Consumption (mgd) : max.: 8.15; avg: 6.25 (86.6 gpcd)
Metered services (%) : 100 (except 120 unmetered fire line services)
Mains (mi) : distr. and trans.: 101.5
Valves: 2,917
Hydrants: 1,080
Revenue ($) : water: 499,170; other: 3,595; total: 502,765
Expense ($) : op. and maint.: 83,307; admin. and general: 53,073; water purchased: 240,345; total: 376,725
Tax paid (% of revenue) : none
Income ($) : 126,042
Bond interest ($) : 2,464
Bond retirement ($) : 23,000
Added to reserve ($) : 30,000
Paid to general fund ($) : 71,578
Book value ($) : 3,268,644
Debt outstanding ($) : 61,000
Unit costs: water ($/mil gal) : 105.

—*J. E. Vogt*

(*Continued on page 66*)

1879—ROSS—1879

Automatic Valves

ALTITUDE VALVE

Controls elevation of water in tanks, basins and reservoirs

1. Single Acting
2. Double Acting

Maintains safe operating pressures for conduits, distribution and pump discharge

SURGE-RELIEF VALVE

REDUCING VALVE

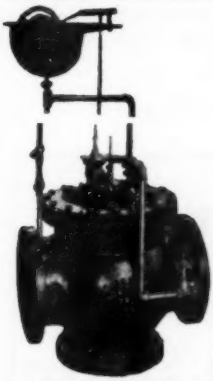
Maintains desired discharge pressure regardless of change in rate of flow

Regulates pressure in gravity and pump systems; between reservoirs and zones of different pressures, etc.

A self contained unit with three or more automatic controls

COMBINATION VALVE

Combination automatic control both directions through the valve.

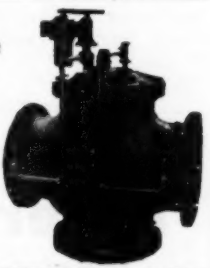


FLOAT VALVE

Maintains levels in tank, reservoir or basin

1. As direct acting
2. Pilot operated and with float traveling between two stops, for upper and lower limit of water elevation.

Electric remote control—solenoid or motor can be furnished



REMOTE CONTROL VALVE

Adapted for use as primary or secondary control on any of the hydraulically controlled or operated valves.

Packing Replacements for all Ross Valves Through Top of Valve

ROSS VALVE MFG. CO., INC., P. O. BOX 593, TROY, N. Y.

(Continued from page 64)

BACTERIOLOGY

Biological Depuration of Waters Subjected to Demineralization by Ion-Exchange Resins. G. LALLI & A. ORLANDI. Riv. Med. Aeronaut., **15**:231 ('52). Expts. were made with *Esch. coli* in distd. H_2O and in sterilized river water, and with naturally impure river water. Weak cation-exchange resins (**I**), like Amberlite IRC-50, were practically inactive, strong **I**, like Amberlite IR-120, were inactive on *Esch. coli* in H_2O but strongly active against acid-sensible microbes contained in water with considerable salt content; weak anion-exchange resins (**II**), like Amberlite IR-4B, were scarcely active; strong **II**, like Amberlite IRA-400, both alone as well as assocd. with **I** in monobeds, were intensely active against all microbes contained in natural waters.—*CA*

Membrane Filter. H. KRUSE. Gas- u. Wasserfach, **93**:712 ('52). Membrane filters are prepd. by evapg. definite quantity of soln. of nitrocellulose on horizontal plate; filter porosity varies with state of polymerization of nitrocellulose as well as with humidity and temp. at which it is used. Pore size of these filters can be estd. by air pressure required to bubble air through layer of water over horizontal filter. They can be sterilized with flowing steam in layer of alternate membrane filters and filter papers, weighted down. Membrane of this type will retain bacteria of much smaller size than pore size and can be used for quant. removal of bacteria from relatively large amts. of water or dil. sewage (up to 1 l or more). After filtration in sterile app., filter is divided into 2 parts with sterile scissors, and ½ is incubated in Petri dishes in contact with Endo media at 41° and other half in contact with Bulir media at 45–46°. At these temps. growth of atypical *Esch. coli* and accompanying flora is suppressed, while growth of warm-blood *Esch. coli* is favored; latter is shown by deep-red colonies on Endo media. Other media can also be used, such as Bi sulfite media on which typhoid bacteria show up as black colonies and *Esch. coli* as gray colonies. Directions for prepg. Endo and Bulir media are given. It is hoped that use of these membrane filters may lead to establishment of international standards for water quality. —*CA*

OTHER ARTICLES NOTED

Recent articles of interest, not abstracted, are listed below.

San Diego Aqueduct Capacity Restored by Chlorination. L. STREICHER. Wtr. & Sew. Wks., **100**:333 (Sept. '53).

The Current Stream Pollution Regulatory Situation. L. L. HEDGEPETH. Wtr. & Sew. Wks., **100**:354 (Sept. '53).

How Philadelphia Has Planned for Universal Metering. G. E. ARNOLD. W.W. Eng., **106**:796 (Sept. '53).

How Albuquerque Tries to Keep up With Phenomenal Growth. O. H. W. BLUME. W.W. Eng., **106**:797 (Sept. '53).

What You Should Know About Soil Engineering. L. J. RITTER. Pub. Wks., p. 94 (Aug. '53).

Filter Sand and Gravel

Well Washed and Carefully Graded to Any Specification.
Prompt Shipment in Bulk or in Bags of 100 lb. Each

Inquiries Solicited

NORTHERN GRAVEL COMPANY

P. O. Box 307 **Muscatine, Iowa**

Dependability

Operators of Roberts-equipped water treatment plants look forward to the same trouble-free service tomorrow that they have come to count on since their equipment was installed. Even in little things, Roberts follows through the years . . . an accidentally broken operating table handle is supplied to match the originals . . . replacement valve parts are shipped from stock or precisely made to the original pattern. Modernization of design has never obsoleted any Roberts equipment.

There has not been, or will there be, an "orphan" with the name Roberts attached. Integrity is built into every piece of Roberts equipment . . . for the years.

Roberts Filter . . . Nameplate of dependability

ROBERTS FILTER

Manufacturing Co.
Darby, Penna.

MECHANICAL EQUIPMENT
BY
ROBERTS FILTER MFG. CO.
DARBY, PENNA.

The Reading Meter

(Continued from page 54 P&R)

Handbook of Selected Biological References on Water Pollution Control, Sewage Treatment, and Water Treatment. *Public Health Bibliography Series No. 8, Div. of Water Pollution Control, Public Health Service, Washington 25, D.C. (1953) 66 pp.; paperbound; free*

This useful bibliography appears to be a handsomer, printed version of the three separate booklets that were mentioned in these columns in August 1952 and January 1953, and attributed at that time to William M. Ingram of the Ohio-Tennessee Drainage Basins Office of the Div. of Water Pollution Control. Illustrations have been added, the book is more agreeable typographically, and some changes have been made in arrangement—presumably to avoid undue repetition when the three major categories are combined in a single booklet.

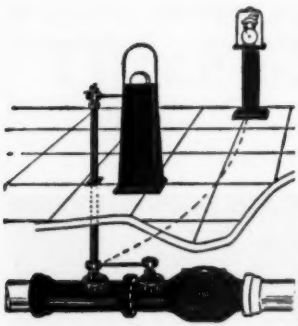
A Suggested Guide to Bidding Procedure. *Document No. 333, American Inst. of Architects, 1735 New York Ave., N.W., Washington 6, D.C. (2nd ed., 1953) 4 pp.; paperbound; free*

This revision of a standard procedure for obtaining competitive lump sum bids is the product of a joint effort by the American Inst. of Architects and the Associated General Contractors of America. One important revision permits a successful bidder who has made an appreciable error to withdraw (not revise) his bid, provided he can support his claim of error with the owner and architect. As the guide recommends that bids be invited from not more than six bidders, preselected for their competence and reputations, it will generally not be usable without modification when open bidding is mandatory, as for many public works projects.

National Electrical Code. *Vol. 5, National Fire Codes. ASA C1; NFPA No. 70. National Fire Protection Assn., 60 Batterymarch St., Boston 10, Mass. (1953) $3.00 clothbound, $1.00 paperbound; 576 pp.*

This latest edition of the National Electrical Code supersedes the 1951 version and contains a number of changes, although mandatory grounding to a water service has not been altered. Among sections affected by the changes are Articles 510 on garages and vehicle repair shops and 710 on high voltage circuits. A new article, 330, permits the use of mineral-insulated metal-sheathed cable (Type MI) for wet locations, or embedded in masonry.

(Continued on page 70 P&R)



SPARLING METERS
for your MAIN-LINES

Whether you require Totalization only, or Rate-Indication and Recording, plus auto-metered control of chemical feeds, Sparling Meters will give you Service and Satisfaction.

Bulletin 313 is yours for the asking.

SPARLING METER COMPANY
INCORPORATED

LOS ANGELES — NEW YORK — CINCINNATI — BOSTON
SEATTLE — ATLANTA — DALLAS — KANSAS CITY

48 miles of CONCRETE pipe assure adequate water supply for Savannah River Project

Producing materials for A and H bombs at the Savannah River Plant in South Carolina requires enormous quantities of water. This water, from the Savannah River, is distributed by 48 miles of concrete pipe on the 315 square-mile site.

Extremely difficult engineering problems were encountered because of the high water table in the area. Many lines had to be laid through swamps and under railroads.

Whether the water line you plan is long or short, concrete pipe offers the rugged strength, long life and economy necessary for satisfactory service. Its tight joints and dense structure prevent leakage and infiltration. Not being subject to damaging internal corrosion, durable concrete pipe maintains constant hydraulic efficiency. It delivers long years of dependable, ***low-annual-cost*** service.

CONCRETE PIPE USED IN SAVANNAH RIVER PROJECT	
48"	410 ft.
54"	5,250 ft.
60"	28,493 ft.
66"	65,225 ft.
72"	23,178 ft.
78"	30,472 ft.
84"	100,529 ft.

PORTLAND CEMENT ASSOCIATION

33 West Grand Avenue, Chicago 10, Illinois

A national organization to improve and extend the uses of portland cement and concrete through scientific research and engineering field work

The Reading Meter

(Continued from page 68 P&R)

For Junior Junior Engineers

A selection of books for children who are learning about the world in which they find themselves should always include at least one on water. The water utility official might well refer parents and teachers to the following titles. They are intended for age levels ranging from preschool (to be read aloud by parent) to junior high.

Water, Water Everywhere. *Ralph B. Raphael; illus. Art Seiden. Wonder Books, Inc., 1107 Broadway, New York 10, N.Y. (1953) 20 pp.; board covers, 25¢*

A good-humored, brightly illustrated outline of water's uses, designed for the very young with a bare minimum (a phrase per page) of rhymed text:

Just the perfect stuff for fishes—
Going wading—
Washing dishes.
It cleans our clothes—
And my, just think—
Water's lovely, just to drink!

Our guess, based on the response of our favorite youngsters, is that this is fine for the three-year-olds.

When Grandma Was a Girl. *Mildred Summit; illus. Sari. Jolly Book No. 215, Avon Publications, Inc., 575 Madison Ave., New York 22, N.Y. (1953) 24 pp.; board covers; 25¢*

For the child of perhaps 4 to 7, this discussion of changes in technology since Grandma's girlhood should be highly entertaining. The heavy emphasis placed upon water supply, both for convenience and firefighting, more than offsets the author's somewhat childish (as opposed to child-*like*) conception of how a modern water system works.

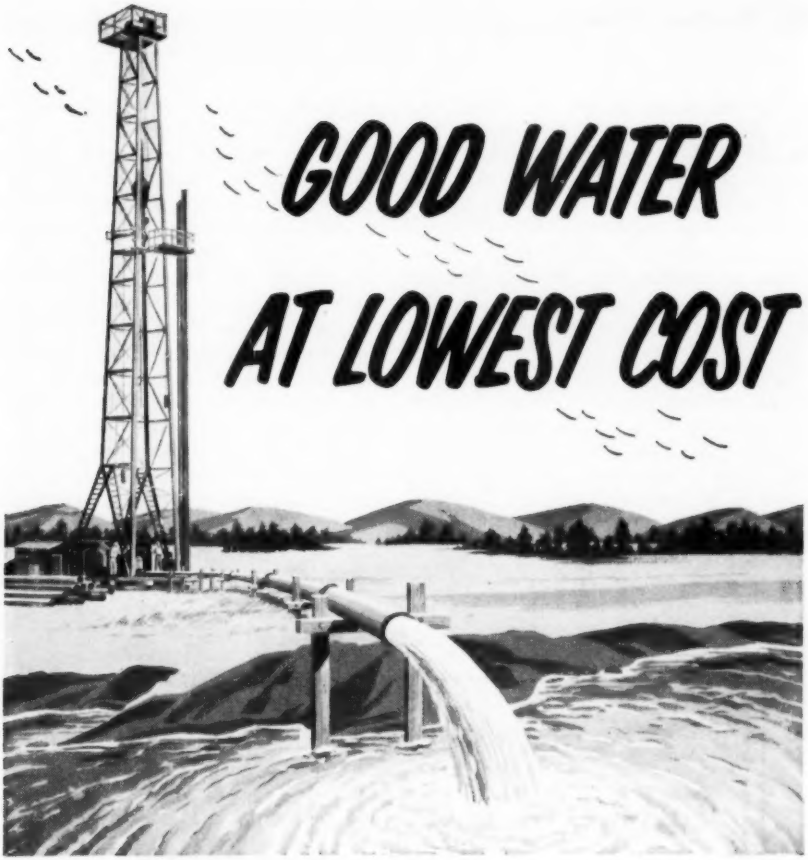
Water Appears and Disappears. *Glenn O. Blough; science verified by Bertha Morris Parker. Basic Science Education Series; Row, Peterson & Co.; 1911 Ridge Ave.; Evanston, Ill. (1943; rev. 1953) 36 pp.; paperbound; 36¢*

This book represents a serious—and, in our estimation, a successful—attempt to explain the hydrologic cycle to second and third graders, and substantial parts of it could well be read to younger children as well. Classroom-type experiments to show how warmth and wind affect evaporation; relation of principles of condensation to such everyday experiences as that of seeing droplets form on the outside of an ice pitcher—all are in the best "here-and-now" tradition of modern learning techniques and at the same time have imagination enough to enlist the interest of the average curious child. The beginning is unfortunate, being unrelated to the rest of the book and apparently designed to bribe the reader (or listener) with promises of wonderful new toys and playthings. When learning is painless, bribes are worse than unnecessary; they are confusing. The cover illustration, featuring bubble-blowing, is also completely extraneous, and therefore a poor choice. Books—and especially pictures—for children normally should be completely literal, particularly if they undertake to give information.

Water. *Bertha Morris Parker; science verified by Margaret Terrell Parker. Basic Science Education Series; Row, Peterson & Co.; 1911 Ridge Ave.; Evanston, Ill. (1944; rev. 1953) 36 pp.; paperbound; 36¢*

For the "intermediate" level (fifth and sixth grades), this book offers a slightly more technical exposition of the hydrologic cycle, the various methods of collecting and distributing water, its many uses, and the part it can play in the lives of people and animals. Actually, the scope of this booklet, including as it does

(Continued on page 72 P&R)



LAYNE CAN HELP YOU GET IT

For 71 years Layne has been planning and producing efficient, economical, dependable water supply systems for municipalities throughout the world. This vast experience can be of benefit to you . . . in developing a new supply . . . in extending your present water system . . . in achieving greater production through overhaul of your existing system.

Call Layne for good water at lowest year-after-year cost. Consult your nearest Layne Associate Company or write direct to:

LAYNE & BOWLER, INC.,
Memphis 8, Tenn.

Layne

Water Wells • Vertical Turbine Pumps

WATER TREATMENT

Layne Associate Companies Throughout the World

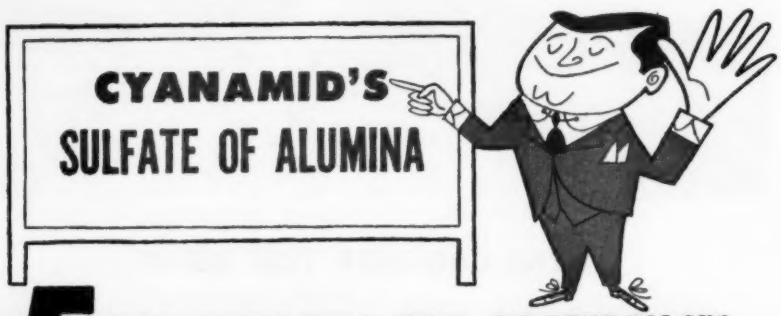
The Reading Meter

(Continued from page 70 P&R)

the formation of fossils, of caves, and even the role of seas in evolution, is far too ambitious to permit any sort of continuity or detailed treatment, and the result is that the child is offered dozens of stimulating but hazy ideas and comparatively little real information. It includes an explanation of the filtering process and (all things considered) a respectable diagram of a filter.

Water Supply and Sewage Disposal. *Bertha Morris Parker; science verified by Horace R. Frye. Basic Science Education Series; Row, Peterson & Co.; 1911 Ridge Ave.; Evanston, Ill. (1946; rev. 1949) 36 pp.; paperbound; 36¢*

At the junior high level (eighth and ninth grades), water supply comes into its own with comparatively full and detailed exposition, verified by the Evanston, Ill., Water Department's own Horace Frye. A stickler could still find fault with details here and there—such as the mention of softening hard water on page 4, long before the meaning of these terms are explained; or the familiar fallacy of considering the New York City water supply "a model for many other cities." On page 16, also, there is a chart showing the chemical analyses of various waters, and we seriously question whether many junior high science teachers could be found who know the meaning of the "equivalents per million" in which it is calibrated, let alone being able to explain it to their pupils. "Parts per million" would have been a much simpler concept. On the whole, however, the booklet is clear, competent, and completely readable.



5 BIG REASONS FOR PREFERENCE!

Waterworks superintendents who depend on Cyanamid's Sulfate of Alumina know these five big reasons for its widespread use:

1. **Uniform, trouble-free feeding**
2. **Wide pH range of coagulation**
3. **Rapid floc formation**
4. **Maximum adsorption of suspended and colloidal impurities**
5. **Minimum corrosion of feeding equipment**

Write today for all the details on how these advantages can help you.

AMERICAN Cyanamid COMPANY
Heavy Chemicals Department
30 Rockefeller Plaza, New York 20, N. Y.
In Canada: North American Cyanamid Limited, Toronto and Montreal

1,000,000-Gal. Reservoir at Pembroke

A Chicago Bridge & Iron Company Field Welding Supervisor was assigned to visit the 1,000,000-gal. welded reservoir shown above, while we were erecting it at Pembroke, N. H. He has the responsibility of checking the operation of welding equipment . . . . seeing that the proper number of test plugs are cut and graded . . . . helping magnaflux or x-ray welded seams . . . . assisting with any other tests called for in the specifications. Field Welding Supervisory Service is provided, at no extra cost to you, on all Chicago Bridge & Iron Company jobs to assure you the best possible structures for your money. Write our nearest office for estimating figures or additional information on Horton tanks.

CHICAGO BRIDGE & IRON COMPANY

BIRMINGHAM CHICAGO TULSA BOSTON CLEVELAND
PHILADELPHIA NEW YORK DETROIT SEATTLE LOS ANGELES
SAN FRANCISCO HOUSTON ATLANTA HAVANA PITTSBURGH

Plants in Birmingham, Chicago, Salt Lake City and Greenville, Pa.

Section Meetings

New York Section: The annual Fall Meeting of the New York Section was held at the Lake Placid Club, Lake Placid, on September 10–11, with a total registration of 375. Mayor George C. Owens officially opened the meeting at luncheon on Thursday with an address of welcome.

James K. Fraser of Barker & Wheeler, engineers, Albany, delivered the opening paper Thursday afternoon. His subject, "Diatomaceous Earth Filters for Municipal Water Supplies," was covered completely, and he referred particularly to the installations at Tupper Lake and Willsboro. Gilbert V. Levin of the District of Columbia Health Dept. continued this discussion by telling of his experiences with "Diatomaceous Earth Filters for Swimming Pools." The purpose of his paper was to indicate weaknesses in design and operation of the filters which have caused major difficulties during his work on government installations. He pointed out that many of the problems he has encountered can be solved by present knowledge, but that further study is still required.

Alan W. Ross, president of Layne-New York Co., Inc., brought the afternoon to a close by giving us a short history of the centrifugal pump and the development of deep well pumps. He illustrated his talk by presenting a color movie, "Deep Water," which showed modern methods of locating and drilling wells.

Cocktails, served to all through the courtesy of the Water and Sewage Works Manufacturers Association, preceded the Annual Banquet. Raymond J. Faust, AWWA executive assistant secretary, told some interesting anecdotes about his experiences with a small midwestern town, and how his efforts to help this town resulted in a good water system. A party after the banquet, sponsored by the Water and Sewage Works Manufacturers Assn., provided dancing and a pleasant opportunity for every one to get together and meet the new members, as well as to chat with old friends.

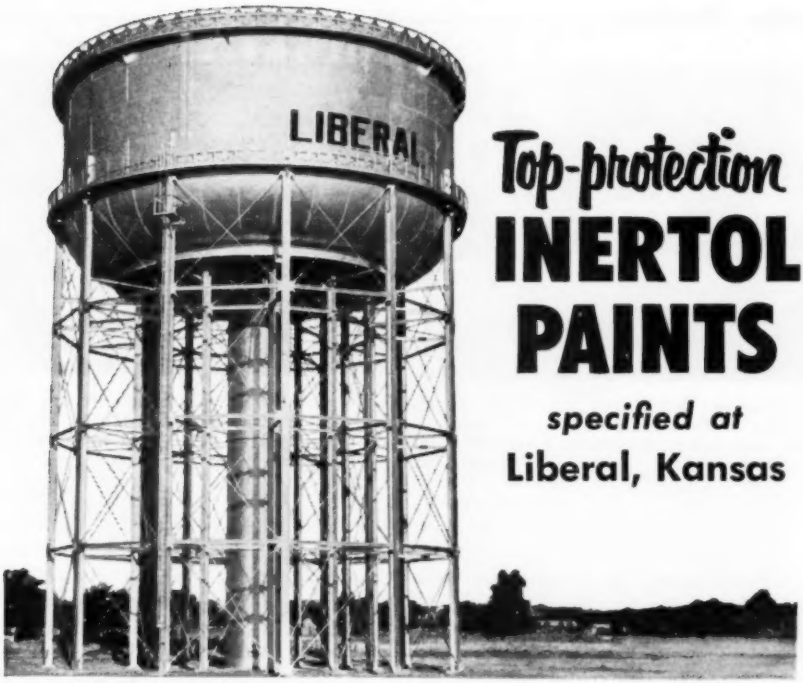
Frank D. Behan, superintendent, Plattsburg, led the Round Table Conference Friday morning. Those attending were able to voice their opinions on the following topics: the rights-of-way of water mains, regulations governing street excavations by utilities, current developments in chemical feed equipment, and new amendments to the sanitary code.

The meeting was a great success in every respect. Registration was the largest in the Section's history, the speakers were excellent, and the fine recreation facilities provided by the Lake Placid Club included golf, swimming, and tennis. For the ladies attending the meeting, there was a bridge tournament and a boat ride on Lake Placid, while the men vied for prizes in a golf tournament.

KIMBALL BLANCHARD
Secretary-Treasurer.

Rocky Mountain Section: The 27th annual meeting of the Rocky Mountain Section was held in Santa Fe, N.M., on September 22–23, at the La Fonda Hotel, with 125 registered. The Program Committee prepared an excellent program, and this, together with the colorful setting of old Santa Fe, was the major reason for attracting the large attendance. The meeting was preceded by a one-day meeting of the Rocky Mountain Sewage Works Assn.

(*Continued on page 76 P&R*)



Top-protection INERTOL PAINTS

specified at

Liberal, Kansas

Inside and outside of this water storage tank got Inertol coatings, Inertol Rust-Inhibitive Primer #621 went on all metal first . . . then the interior was painted with Inertol Bakelite Resin Aluminum. For sparkling lasting beauty, exterior was coated with Glamortex Aluminum #320, one of Inertol's structural steel and tank paints. The tank was constructed by Pittsburgh Des Moines Steel Co. Inertol has already been specified for Liberal's proposed filter plant and municipal docks.

Wichita Engineer H. R. Hunter chose Inertol Paints for long wear, looks and economy!

In specifying paint for this gigantic 1,000,-000-gallon elevated storage tank in Liberal, Kansas, Consulting Engineer H. R. Hunter of Wichita wanted coatings that would meet the requirements of water-, weather- and fume-resistance. That's why Inertol Paints topped his list! They far exceed specifications for hardness, elasticity, lime- and water-resistance.

Time and again, the top-protection qualities of Inertol Paints have been proved in thousands of installations all over the United States. Our Field Technicians welcome the chance to talk over your painting problems—and to help you choose the Inertol coatings to solve them.

Or send for our free "Painting Guide." If you're a Specification Writer, Design Engineer, Plant Superintendent or Contractor, you'll find this informative pamphlet invaluable!

Write for your free copy *today!*

INERTOL CO., INC.

484 Frelinghuysen Avenue
Newark 5, New Jersey

27G South Park
San Francisco 7, California

Section Meetings

(Continued from page 74 P&R)

Enjoying the banquet at the Rocky Mountain Section Meeting in Santa Fe are (left) William F. Turney, newly elected trustee, with Mrs. Turney, and Gordon E. Herkenhoff; and (right) Secretary-Treasurer George J. Turre, Mrs. Turre, and the new vice-chairman, Thomas J. Eaton.

Tuesday morning was devoted mostly to registration. Gerald Clark, director of the New Mexico Dept. of Public Health, officially welcomed the group; Chairman Bennett followed with committee appointments, after which Dale L. Maffitt, AWWA vice-president, addressed the group. An excellent paper prepared by Glenn E. Hands, engineer of Burns & McDonnell, and read by R. H. McDonnell, was "Problems of Water Works in a Rapidly Expanding Community."

The Tuesday afternoon session was devoted to a panel discussion on "Fluoridation of Public Water Supplies," with Charles Wright, U.S. Public Health Service, and Charles G. Caldwell, director of the Div. of Sanitary Engineering and Sanitation, New Mexico Dept. of Public Health, as the principal speakers. Other highlights of the Tuesday session were the paper entitled, "Watershed Recreational Problems," presented by Fred A. Thompson, director of fisheries, Dept. of Game and Fish, Santa Fe, N.M., and the open discussion which followed.

The Wednesday morning meeting began with a paper entitled "Development of the Law of Underground Waters" by Charles D. Harris, special assistant attorney general, Field Office of State Engineer, Roswell, N.M. William F. Turney of Herkenhoff and Turney, consulting engineers, Santa Fe, presented a paper entitled, "The Consulting Engineer's Contribution in Evaluating and Designing Municipal Facilities." R. C. Stelle, associate engineer, New Mexico Dept. of Public Health, presented a paper entitled, "Location, Development, and Protection of Ground Water Supplies."

A business luncheon was held Wednesday noon at the Santa Fe Country Club with 74 in attendance. The usual reports of the auditor, secretary and tellers were given. Vice-President Maffitt presented some of the highlights of the last meeting of the Board of Directors held in New York. The following officers for 1953–54 were elected: chairman, V. A. Vaseen, Denver; vice-chairman, Thomas J. Eaton, Santa Fe; secretary-treasurer, George J. Turre, Denver. Two new trustees from New Mexico were elected for a three-year term: William F. Turney, Santa Fe, and Otto Blume, Albuquerque.

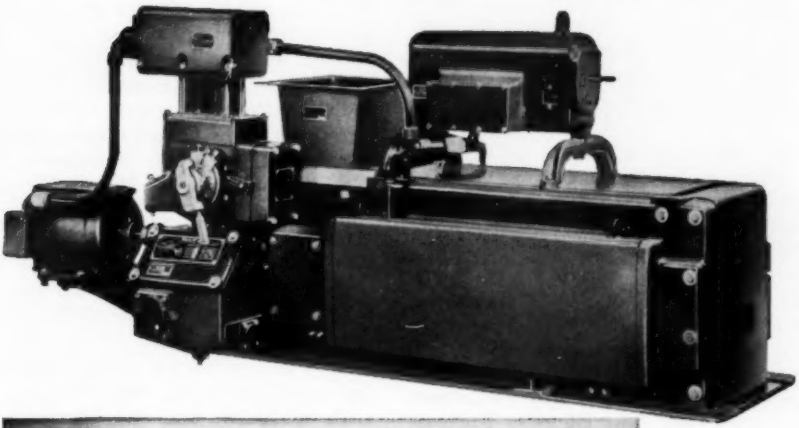
The program on Wednesday afternoon consisted of a round-table discussion of water works problems and a paper entitled "Correlation Between the Civil Defense Command and the Municipal Water Works," by D. H. McNally, general engineer at the Dallas office of the Civil Defense Administration.

Wednesday evening the banquet was held in the Coronado Room of the La Fonda Hotel with 156 in attendance. During the dinner, delightful music was

(Continued on page 78 P&R)

The best "WEIGH" . . . is the MERCHEN way!

W&T Merchen Feeders give precision feeding of any waterworks chemical . . . *by weight.*



FEATURES:

—Continuous, minute-to-minute accuracy.

—Durable construction, sealed bearings and dust shields.

—Automatic built-in alarm switch.

—Knife edges and pivots tipped with special alloy for long life.

—Remote feed rate adjustment if desired.

—Adaptable to fully automatic proportional control.

Hundreds of installations feeding waterworks chemicals, industrial chemicals and feed and flour ingredients have proved the accuracy and dependability of these belt-type gravimetric feeders.

M-24

USE W&T FEEDERS FOR
Dependable Chemical Control

WALLACE & TIERNAN
COMPANY, INC.
CHLORINE AND CHEMICAL CONTROL EQUIPMENT
NEWARK 1, NEW JERSEY — REPRESENTED IN PRINCIPAL CITIES

Section Meetings

(Continued from page 76 P&R)

furnished by Spanish musicians. Newly elected officers were introduced by Chairman Bennett, and Vice-President Maffitt spoke briefly upon the importance of the water works man in public affairs. Gerald Clark, as the principal speaker, discussed the importance of the water works to public health. The Gold Lapel Pin of AWWA was then presented to the outgoing Chairman Bennett by Chairman-Elect V. A. Vaseen. Entertainment followed, consisting of four musicians from Las Cruces, N.M., who kept the crowd happy with their songs and pantomimes. A group of Santa Fe high school students, known as the Santa Fe Fireflies, danced and were well received by all. After the banquet and entertainment, music for dancing was provided in the New Mexican Room by the Spanish orchestra.

A most interesting and enjoyable program was provided for the ladies. This consisted of a tour of Santa Fe; a tour of Tesuque and San Ildefonso Pueblos; the Folk Art Museum; a visit to the Bishop's Lodge; and a delightful bridge-luncheon at the La Posado.

A most delightful cocktail party also was given on Tuesday at the La Posado, through the courtesy of Herkenhoff & Turney, consulting engineers of Santa Fe. This was enjoyed by all those who attended.

The technical sessions were well attended, and the excellent program of entertainment presented was enjoyed by all who attended the meeting in Old Santa Fe—"at the end of the trail."

GEORGE J. TURRE
Secretary-Treasurer

Minnesota Section: The 37th Annual Convention of the Minnesota Section, bringing together members from Minnesota, North and South Dakota, and Canada, was held in Winnipeg, Man., September 1–5, 1953, at the Royal Alexandra Hotel, with N. S. Bubbis, general manager of the Greater Winnipeg Water Dist., presiding as Section chairman. This was the second meeting of the Section outside of the States, as the 1948 convention was also held in Winnipeg.

Both the 1948 and 1953 meetings were exceptionally successful. There were 166 in attendance this time, and, in addition, 91 ladies registered. A preconvention get-together and clubroom was held through the courtesy of the Canadian Water Works Equipment Manufacturers and Contractors. A second clubroom feature preceded the Friday evening banquet, provided through the courtesy of the U.S. Water & Sewage Works Manufacturers Assn.

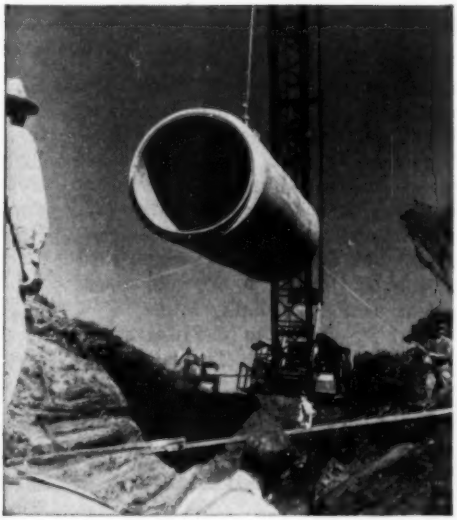
One afternoon was devoted to an inspection tour of the Winnipeg water system, pumping stations, and operating offices. A number of demonstrations were held for the delegates. Following the close of the convention, a most interesting and enjoyable all-day trip by train was made to Indian Bay, the source of the Winnipeg water supply, through the courtesy of the Administration Board of the Greater Winnipeg Water Dist. Many entertainment features were held especially for the ladies, and others were shared with the ladies. An exceptionally pleasant evening and fine dinner was tendered all the delegates and their wives by the city of Winnipeg at the city's beautiful Assiniboine Park Pavilion.

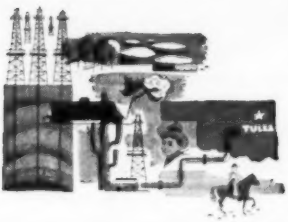
The sessions provided many interesting and instructive papers, including panel discussions on distribution system records; cold weather operation of a distribution system; laboratory tests, chemicals and equipment for a small plant; economics of water softening; mechanical joint pipe practice; wartime water contamination; and a paper by Past-President A. E. Berry on "The Water Works Industry Looks at Fluoridation."

The convention was honored with the attendance of Dale L. Maffitt, AWWA vice-president, who delivered a most timely and interesting talk to the mem-

(Continued on page 80 P&R)

Tulsa Prefers Concrete Pressure Pipe





In 1923 when Tulsa reached out to Spavinaw Creek for pure, spring-fed water it selected concrete pressure pipe for the flow line. Fifty-two miles of 54- and 60-inch concrete pressure pipe were installed to carry a maximum of 25 mgd.

Twenty-eight years later Tulsa again chose concrete pressure pipe to help increase its water supply. The new line, completed last year, parallels the original installation and boosts Tulsa's capacity to 63 mgd. 66- and 72-inch pipe were used.

The confidence Tulsa engineers have in concrete pressure pipe is evidenced by the fact that it was selected a second time for the city's water supply system. The original installation had proven that concrete pressure pipe is efficient, economical, and lasting.

If your city is planning additional water lines, or replacements for old lines, be sure to investigate the distinct advantages of concrete pressure pipe.

Water for Generations to come

Concrete PRESSURE Pipe

AMERICAN CONCRETE PRESSURE PIPE ASSOCIATION
228 North LaSalle Street
Chicago 1, Illinois

Section Meetings

(Continued from page 78 P&R)

bers. New officers elected were Mr. George J. Schroepfer of Minneapolis as chairman, Howard J. Sowden of Fergus Falls as vice-chairman, and M. D. Lubratovich of Duluth as Trustee. The Fuller Award was recommended for Edgar W. Johnson, water works engineer of Minneapolis, and the R. M. Finch Award was made to Howard J. Sowden, superintendent at Fergus Falls, Minn.

LEONARD N. THOMPSON
Secretary-Treasurer

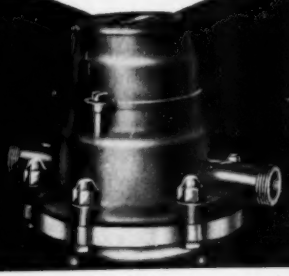
Michigan Section: The fifteenth annual meeting of the Michigan Section was held in Escanaba on September 3–4, 1953. A total of 225 attended, 61 of whom were women.

The technical meetings were held in the Bonifas Auditorium. After the meeting was duly called to order by Chairman E. D. Barrett and welcomed by Mayor R. E. LeMire, two papers were heard at the morning session. "News From the Field" by John E. Vogt of the Michigan Dept. of Health and "Compensation for the Superintendents of Water Works" by Raymond J. Faust, AWWA executive assistant secretary. Escanaba's new water filtration plant was a center of interest for an inspection trip and a paper on "Design Factors of the Escanaba Filtration Plant" by P. H. Johnson.

A paper by T. L. Vander Velde on "Water Supplies in Disaster" recounted the effects of recent tornadoes at Port Huron and Beecher Metropolitan Dist. A panel discussion on "Handling, Feeding, and Testing of Fluorides," was led by W. E. Harris and presented S. DeBoer, H. W. Greene, G. Hazey, W. Muhlitner, and A. Sabo in a discussion that was very

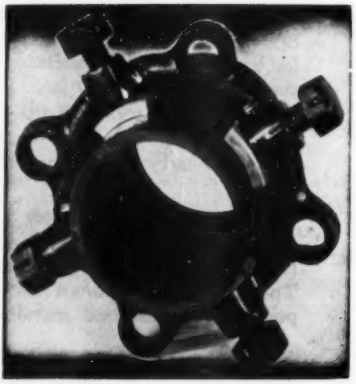
(Continued on page 82 P&R)

SIMPLICITY of American Meters PAYS OFF for You!



Buffalo AMERICAN Meters are simply designed, with fewer working parts — save money for you through lower maintenance and replacement costs. Write for details.

BUFFALO METER COMPANY
2914 Main Street
Buffalo 14, New York



ANCHORED CLAMP for MECHANICAL JOINTS

Also CI-60 charcoal cast iron bolts for mechanical joints; bell-joint Leak Clamps and Gasket Sealer Compound.

Write for information

H. Y. CARSON COMPANY
1221 Pinson St. Birmingham, Ala.

When pipe efficiency drops you need... **National**

When pumping costs rise, pressures fall and capacity is way down—
You need *National* cleaning!

Often, lines assumed to be in top operating condition are actually delivering less than half of their rated capacity. For instance—a tuberculated 48" pipe, having a co-efficient of 93 can carry no more water than a clean 42" pipe. Think how much difference this makes in costs when it must be compensated for by either greater power consumption at the pumping station or by larger mains in the ground.

Remember, the National Water Main Cleaning Company *guarantees* to restore any water main to 95% of its original carrying capacity.

There's no obligation when National's engineers inspect and estimate cleaning costs of your mains, so write or phone today!

NATIONAL WATER MAIN CLEANING COMPANY
50 Church Street • New York, N.Y.

37

ATLANTA, GA; 333 Candler Building • BERKELEY, CALIF; 905 Grayson Street • DECATUR, GA; P. O. Box 385 • BOSTON, MASS; 115 Peterboro Street • CHICAGO; 122 So. Michigan Avenue • ERIE, PA; 439 E. 6th Street • FLANDREAU, S.D; 315 N. Crescent Street • KANSAS CITY, MO; 406 Merchandise Mart and 2201 Grand Avenue • LITTLE FALLS, N.J; BOX 91 • LOS ANGELES; 5075 Santa Fe Avenue • MINNEAPOLIS, MINN; 200 Lumber Exchange Building • RICHMOND, VA; 210 E. Franklin Street • SALT LAKE CITY; 149–151 W. Second South Street • SIGNAL MOUNTAIN, TENNESSEE; 204 Slayton Street • MONTREAL, CANADA; 2032 Union Avenue • WINNIPEG, CANADA; 576 Wall Street • HAVANA, CUBA; Lawrence H. Daniels, P. O. Box 531 • SAN JUAN, PUERTO RICO; Luis F. Caratini, Apartado 2184.

Section Meetings

(Continued from page 80 P&R)

interesting and helpful for others starting fluoridation programs.

Another panel composed of J. Rubbo as leader, R. Harwood, H. Huntley, A. Sabo and Paul Stegeman, offered an exchange of ideas on "Labor Saving Devices in Water Supplies." R. S. Dark of the Bailey Meter Co. gave a paper on "Centralizing Instrumentation and Control for Water Plants." The closing paper by W. F. Shephard, Director of the Div. of Engineering of the Michigan Dept. of Health, entitled "The Water Works Industry Looks Ahead," proposed challenges to every water works man.

The manufacturer's representatives again in cooperation with the Water and Sewage Works Manufacturer's Assn. proved to be very cordial hosts in providing the clubroom for all attending.

The annual banquet was the occasion for many to receive honors. Earl E. Norman of Kalamazoo was nominated to receive the George Warren Fuller Memorial Award for his efficient and capable direction of the expansion and operation of his city's water supply; and for his deep interest and devotion to the activities and growth of the Michigan Section." Life memberships were awarded to Frank D. Libby and Leo E. McQueen. Fifty-nine persons received the Edward D. Rich Service Award for 25 years of meritorious and faithful service in providing and maintaining a safe and adequate water supply in Michigan.

Entertainment and trips were unique to the area. A log birling contest by father and son Girard provided many thrills. A train excursion was made possible by the Soo Railroad to the iron ore loading docks in Bay DeNoc. The ladies were given a most delightful afternoon on sailboats provided by members of the

(Continued on page 84 P&R)

MUNICIPAL SUPPLIES

TRAFFIC SIGNALS
WATERWORKS
SEWERS
STREETS
POLICE
FIRE EQUIPMENT

W.S. DARLEY & CO.
CHICAGO-12-ILLINOIS
No. 148

WRITE TODAY
For
100 PAGE CATALOG
W. S. DARLEY & CO. Chicago 12

TC
TENNESSEE CORPORATION

SODIUM
FLUOSILICATE
(Silico Fluoride)

Inquiries Invited

TENNESSEE TC CORPORATION
1028 CONNECTICUT AVE., N. W.
WASHINGTON 6, D. C.

Chlorine is Tamer with these CRANE Valves

. . . Designed to handle water-free chlorine, gas or liquid up to 300° F.

Your best valves for handling chlorine are those made expressly for this service. It's too tough for ordinary equipment.

Rugged Construction

You'll operate more safely, efficiently, and dependably with these Crane Chlorine Valves. Their rugged forged steel construction gives you protection against internal and external shock. You'll have freedom from bonnet joint leakage with their strong Crane bolted design.

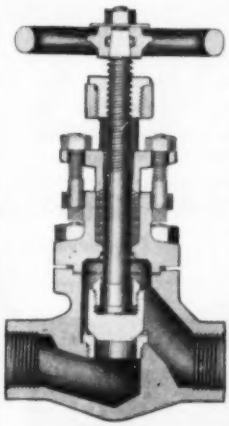
Effective Corrosion Resistance

You'll be equipped for highest resistance to corrosion with the Hastelloy "C" disc and seat rings, and the Monel stem! A corrugated soft Monel gasket prevents corrosion and leakage at the bonnet joint.

Literature Free on Request

The many refinements of Crane Chlorine Valves assure not only more efficient chlorine control, but important savings on valve maintenance and replacement costs. Get the complete facts in Circular AD-1608. Write or ask your Crane Representative for a copy.

EVERY FEATURE WORKS FOR YOU



Strong one-piece forged carbon steel yoke with outside screw out of contact with fluid.

Husky Monel stem; easy to lubricate threads.

Easy to pull up bolted gland of forged carbon steel.

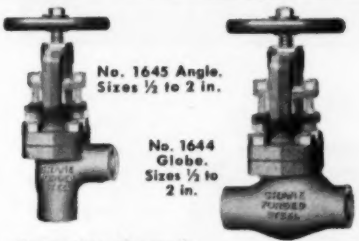
Deep stuffing box.

Leakproof male and female bolted bonnet joint with corrugated soft Monel gasket.

45° narrow bearing seat; closes tight, even with hard deposits.

Highly corrosion-resistant Hastelloy "C" in seating parts.

Heavy forged carbon steel body; long end threads.



No. 1645 Angle. Sizes ½ to 2 in.

No. 1644 Globe. Sizes ½ to 2 in.

These valves also available with flanged ends.

for the THRIFTY BUYER

THE BETTER QUALITY...BIGGER VALUE LINE...IN BRASS, STEEL, IRON

CRANE VALVES

CRANE CO., *General Offices:* 836 S. Michigan Ave., Chicago 5, Illinois
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

Section Meetings

(Continued from page 82 P&R)

Escanaba Yacht Club. One dunking experience only proved to make the trip more interesting. A tour through the Birdseye Veneer Plant was enjoyed by the ladies on Friday morning.

T. L. VANDER VELDE
Secretary-Treasurer

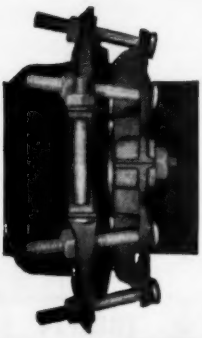
West Virginia Section: The 1953 meeting of the West Virginia Section was a hot one; the meeting date of September 3–4 coincided with the peak of the most extreme heat wave recorded in West Virginia since the record-breaking drought of 1930. High temperatures not only reduced attendance but wilted down those who sat through technical sessions in 102° heat. Although water was forced to compete with weather as the chief topic of conversation, a well balanced program was appreciated by those attending.

The meeting was held at Morgantown, with headquarters at the Hotel Morgan. All technical sessions were held in an auditorium at the Mineral Industries Bldg. of West Virginia University. A total of 120—approximately 20 below average—registered for the water works meeting, not including ladies and guests.

The first technical session, with Chairman Nick Leshkow presiding, was held the morning of September 3 and opened with a showing of the Aluminum Co. of America film, "Curiosity Shop." This was followed by an address by A. E. Griffin, director, Technical Service Div., Wallace & Tiernan Co., Newark, N. J., on "The Preparation and Use of Chlorine-Activated Silica." The next item on the program was a practical presentation on "Maintenance and Repair of Water Meters" by representatives of the

(Continued on page 86 P&R)

FOR REPAIRING BELL AND SPIGOT JOINT LEAKS...



The only clamp with these two important features. Gasket is completely SEALED. Massive ¾" electroplated bolts. 2"—42" incl.

Write for Catalog.

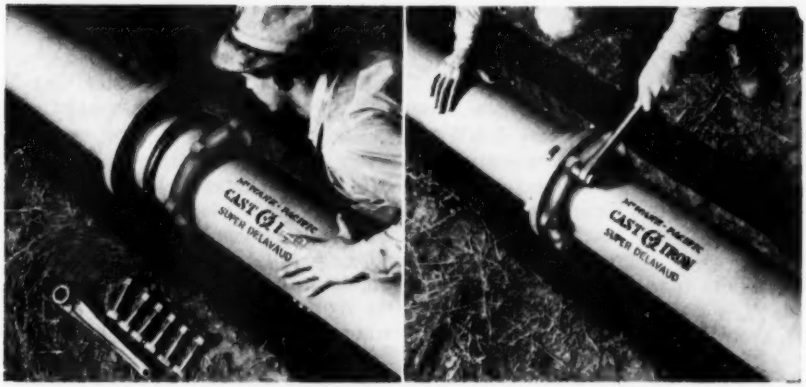
M. B. SKINNER CO.
SOUTH BEND 21, INDIANA, U.S.A.

6 Reasons why
WALKING BEAM FLOCULATION
is now specified by
water works engineers

1. Eliminates troublesome underwater bearings.
2. Eliminates expensive dry well construction.
3. All bearings accessible for inspection and lubrication.
4. Produces quick responsive floc formation.
5. Longer filter runs.
6. A saving in alum.

Write today for Bulletin 451 and a list of water purification plants that have gone modern.

STUART CORPORATION
516 N. CHARLES ST., BALTIMORE 1, MD.



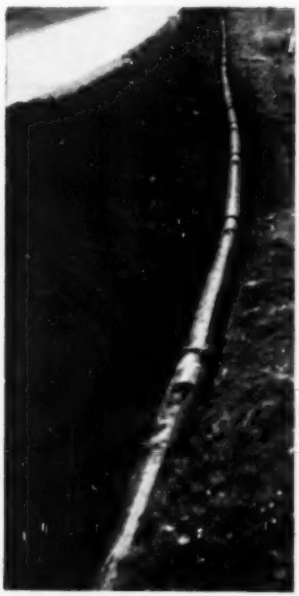
EASY TO LAY

WITH UNTRAINED LABOR

SAVES TIME REDUCES COSTS

McWane-Pacific Boltite mechanical joint pipe and fittings lay faster and reduce pipe line construction costs because the joints can be made by untrained workmen using only a ratchet wrench. Boltite is a better joint for either water or gas. Bottle-tight, leak-proof, yet flexible to allow settlement, or expansion and contraction of the pipe line.

All joint parts, glands, gaskets and bolts are interchangeable with pipe, fittings, valves and hydrants made by other manufacturers. For complete information, wire or write McWANE CAST IRON PIPE COMPANY, Birmingham, Alabama, or PACIFIC STATES CAST IRON PIPE COMPANY, Provo, Utah. (Sales offices in principal cities.)



McWANE PACIFIC PIPE *Lasts for Centuries*

Section Meetings

(Continued from page 84 P&R)

Badger Meter Mfg. Co.—Russ Olsen of Nashville, Tenn., and M. B. Stewart of Shinnston, W.Va. The highlight of the morning was a timely address by AWWA Secretary Harry Jordan on the subject "Can We Keep the Consumers and the Pipes Happy at the Same Time?" Mr. Jordan pointed out that today's highly purified waters depreciate distribution system piping at an accelerated rate, compared with the untreated waters of 75 years ago. The importance of the problem is recognized when one learns that 25,000,000 tons of cast-iron pipe is in use today in water systems.

The second technical session opened the afternoon of September 3 with a presentation of the film "Metallizing—Its Practical Applications" by Metallizing Engineering Co. of Long Island City, N.Y. In discussing "The Advantages of Caustic Soda in the Treatment of Water Supplies Containing Acid Wastes," Dwight L. Jack, chemist, Natrona Water Co., Natrona, Pa., described the successful use of caustic soda instead of lime in treating water at Natrona. He was followed by R. L. Henry of the Pennsylvania Salt Mfg. Co., Philadelphia, who furnished information about the packaging, handling, and use of caustic soda. Martin Flentje, research engineer, American Water Works Service Co., Philadelphia, presented data to show the advantages of using caustic soda in place of lime at the Morgantown, W.Va., treatment plant. In a concise, scholarly review, Eskel Nordell, administrator of laboratories, Permutit Co., New York, described the various processes used in "Municipal and Industrial Water Softening."

Following the technical session a brief business meeting was held. The Fuller Award Committee presented no candidate.

(Continued on page 88 P&R)

THE AMERICAN AGRICULTURAL CHEMICAL COMPANY — AA QUALITY

For Public Water Fluoridation

Sodium Silicofluoride—98%

(Dense Powder)

Sodium Fluoride—97%

(Dense Powder or Granular)

Meets AWWA specifications

White or tinted blue
Minimum of dust in handling
Minimum of storage space

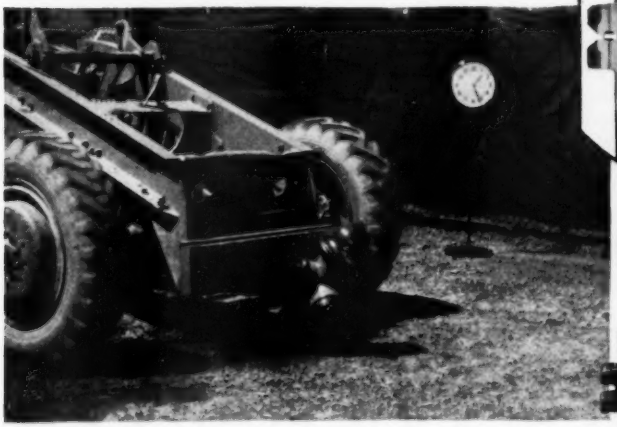
Available in bags and drums

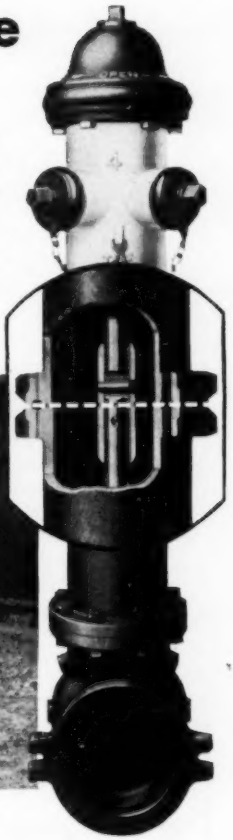
The AMERICAN AGRICULTURAL CHEMICAL Co.

50 Church Street, New York 7, N. Y.

From Break to Service *in 11 minutes . . .*

• **THE KENNEDY SAFETOP** is the only hydrant with the threaded breaking ring that gives positive connection and rigid alignment of the two standpipe sections. Extensive tests and actual service reports show that the Kennedy *Safetop* can stand as tough a blow as the conventional hydrant without damage. But under a smashing impact, it always breaks cleanly at the breaking ring, without damage to working parts.





SHEARED OFF by a heavy road-scraper at 1:26, the Kennedy *Safetop* breaks evenly at the ground level.

Photos taken at N. Y. State Section meeting, A.W.W.A., April 1949.

WITH ONLY an inexpensive *Safetop* Repair Kit and a few common tools, one man can permanently repair the Kennedy *Safetop*.

NO NEED FOR DIGGING because breakage is all above ground . . . no flooding because compression-type valve closes with water pressure.

IN JUST 11 MINUTES the Kennedy *Safetop* is back in service . . . working as smoothly and efficiently as if nothing had happened.

WRITE FOR SAFETOP BULLETIN 105

THE KENNEDY VALVE MFG. CO. • ELMIRA, N.Y.

Est. 1877

VALVES • PIPE FITTINGS • FIRE HYDRANTS

Section Meetings

(Continued from page 86 P&R)

The annual banquet held at the Hotel Morgan during the evening of September 3 was a joint affair with the West Virginia Sewage & Industrial Wastes Assn. It was strictly a "shirt sleeve" affair, with collar-wilting temperatures in the non-air-conditioned ballroom on the top floor of the hotel. Professor G. R. Spindler, director, School of Mines, West Virginia University, Morgantown, was toastmaster. Entertainment consisted of a one-act comedy presented by the Morgantown Community Players.

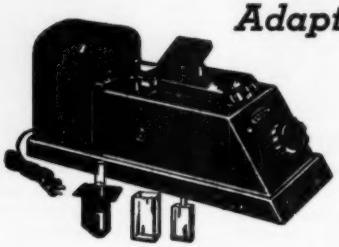
The September 4 program with J. J. Dwyer presiding opened with a showing of the Layne-Ohio Co., film, "Deep Waters." This was followed by two papers dealing with well cleaning techniques. H. W. Pitts, staff sanitary engineer, Willow Island Plant, Calco Chemical Div., American Cyanamid Co., Willow Island, W.Va., described an experience with well acidizing at Shrewsbury, and Chairman Nick Leshkow gave an account of a successful well restoration at Princeton, W.Va.

Dr. James W. Ruble, director, Bureau of Dental Health, State Dept. of Health, Charleston, presented a "Pictorial Report on the Dental Health of Children Living in a Natural Fluoride Area of West Virginia." Close-up color slides of teeth of all children in a small community using a 1.5-ppm natural fluoride water were shown to dramatize the protection afforded by fluoridation.

Following some comments by Professor H. W. Speiden, head, Dept. of Civil Engineering, West Virginia University, Morgantown, about the Morgantown water supply, the meeting adjourned for an inspection tour of the Morgantown filtration plant. This concluded a successful meeting.

H. K. GIDLEY
Secretary-Treasurer

KLETT SUMMERSON
ELECTRIC PHOTOMETER



Adaptable for Use in Water Analysis

Can be used for any determination in which color or turbidity can be developed in proportion to substance to be determined

KLETT MANUFACTURING CO.
179 EAST 87th STREET · NEW YORK, N. Y.

THOROUGH "CHECK-UP" BY A SPECIALIST...

assures long life for pipe. This Barrett service representative is checking a freshly applied coating of coal-tar enamel lining. It measures only 3/32 of an inch—yet without it steel pipe would be a soft touch for corrosion, tuberculation and a score of other hazards which drastically reduce the length of service of pipe lines.

That's why it pays to specify Barrett for pipe-line protection. You get the best protective coatings possible, plus the experienced services of Barrett's Technical Service Group. From blueprint to back-fill these highly trained men are paid by Barrett to assist you!

*Reg. U. S. Pat. Off.

Listed here are 10 definite advantages of Barrett Waterworks Enamel, which meets A.W.W.A. standards.

- **Rigid quality control**
- **Prevents tuberculation and incrustation of interior pipe surfaces**
- **Effectively protects external pipe surfaces against corrosion**
- **High dielectric properties**
- **Impermeable to moisture, non-absorptive, non-porous**
- **High ductility and flexibility, high resistance to soil stresses**
- **Unusual tenacity**
- **Effective under all kinds of climatic conditions and topography**
- **Quick service**
- **Wide availability**

BARRETT DIVISION

ALLIED CHEMICAL & DYE CORPORATION
40 RECTOR STREET, NEW YORK 6, N. Y.

In Canada: The Barrett Company, Ltd., 5551 St. Hubert St., Montreal, Que.

Service Lines

A fluoride feeder that features dustless handling of a full 100-lb bag of chemical is described in a 4-page folder, Bul. 50-K3, distributed by Omega Machine Co., Box 1342, Providence 1, R.I. The unit is known as the Model 50 volumetric Fluoridizer.

Key switches, low-voltage lamps, jack strips, and plugs are featured in a 28-page catalog of telephone-type switchboard equipment offered by Automatic Electric Co., 1033 W. Van Buren St., Chicago 7, Ill.

Economical, in-plant production of sound slide films at a cost in expendable materials of less than $20 is the subject of a 20-page booklet offered by Minnesota Mining & Mfg. Co., St. Paul, Minn. The process calls for use of tape recorder and flash-bulb-equipped camera.

"Standards Are Your Business" is the title of a 24-page booklet distributed by the American Standards Assn., 70 E. 45th St., New York 17, N.Y., in an effort to explain its purposes, methods, and achievements to businessmen. Concrete examples of savings effected by well-known firms are cited.

A Sequestrene bibliography for 1952 has been prepared by Alrose Chemical Co., Box 1294, Providence 1, R.I., to help disseminate recent developments with its product, ethylenediamine tetraacetic acid (EDTA). In water analysis, of course, EDTA is used for hardness determinations.

Electrical tests and the necessary equipment for making them are the subject of a 16-page "Buyer's Guide for Testing Instruments" offered by General Electric Co., Schenectady 5, N.Y. Hook-on ammeters, wattmeters, and power-factor meters; various recorders; and phase-sequence indicators are included.

Horton steel reservoirs and standpipes of 50,000- to 10,000,000-gal. capacity form the basis of a handsome 24-page picture-story presentation illustrated by photographs of actual installations. Various architectural and ornamental treatments are shown, and distribution system storage and fire protection are featured in the booklet, which also gives some information on the Horton pickling process. The bulletin is distributed by Chicago Bridge & Iron Co., 332 S. Michigan Ave., Chicago 4, Ill.

A folder cataloging standard sizes and lengths of wrought-iron nipples in diameters up to 12 in. is offered by A. M. Byers Co., Clark Bldg., Pittsburgh 22, Pa.

STEEL PIPE chosen for U. S. Government's new $4,500,000 walk-through piping tunnel

Upon completion of a $4,500,000 walk-through piping tunnel now under construction at the nation's capital, four major government buildings will receive and return cooling water for their air-conditioning systems through a vast network of Alco Electric Welded Steel Pipe.

Main lines in the network will be 30-in. in diameter and will total about 9,280 ft in length. Branch lines will range from 8 to 20-in. in diameter and total about 1,200 ft.

Electric Welded Steel Pipe is selected for water-supply installations all across the country on the basis of 4 simple, sound, dollars-and-sense reasons:

One, it's strong and resilient—vibration, impact and overloading that shatter other types of pipe leave Electric Welded Steel Pipe unaffected. *Two*, it's efficient—it's positively watertight, and the smooth tar-enameled surface gives maximum rate of flow. *Three*, it's economical—first cost is low; and delivered in long, light sections, it takes minimum time and labor to install. *Four*, it's durable—conservative estimates put its life at 75 to 100 years.

Alco Electric Welded Steel Pipe can be fabricated to meet almost any specifications. Sizes run to whatever practical lengths the available transportation will carry. Pipe 30-in. in diameter and over is made in lengths up to 40 ft without girth seams. Pipe under 30-in. in diameter is made in 22 ft lengths without girth seams (or longer lengths with girth seams).

Whatever the nature of your own installation—be it large or small, special or standard—give Alco Electric Welded Steel Pipe your careful consideration. For complete technical data—and for expert help with your own special problems—contact your nearest Alco Products sales representative.

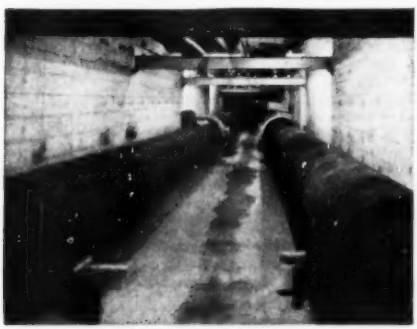
Remember these Key features of Alco Steel Pipe

STRONG: Unaffected by vibration. Maximum resistance to shock, and to overloading due to earth movement and washouts.

EFFICIENT: Positively watertight. Minimum number of field joints. Smooth coal-tar enameled interior surface for highest rate of flow.

ECONOMICAL: Low first cost. Long lengths, light weight, for easy installation.

DURABLE: Life in water-supply installations estimated conservatively at 75 to 100 years.



30-IN. CHILLED WATER LINES of long lasting Alco Electric Welded Steel Pipe in new walk-through tunnel now under construction at Washington, D. C., will total approximately 9,280 ft.

ALCO

ALCO PRODUCTS DIVISION
AMERICAN LOCOMOTIVE COMPANY
DUNKIRK, N. Y.

Sales Offices: New York, Chicago, Dunkirk, Los Angeles, Kansas City, Houston, Tulsa and Beaumont.

Index of Advertisers' Products

Activated Carbon:
Industrial Chemical Sales Div.
Permutit Co.

Aerators (Air Diffusers):
American Well Works
Infilco Inc.
Permutit Co.

Air Compressors:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
Morse Bros. Mchy. Co.

Alum (Sulfate of Alumina):
American Cyanamid Co., Industrial Chemicals Div.
General Chemical Div.

Ammonia, Anhydrous:
General Chemical Div.

Ammoniators:
Everson Mfg. Corp.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.

Brass Goods:
American Brass Co.
M. Greenberg's Sons
Hays Mfg. Co.
James Jones Co.
Mueller Co.
Welsbach Corp., Kitson Valve Div.

Carbon Dioxide Generators:
Infilco Inc.
Walker Process Equipment, Inc.

Cathodic Protection:
Electro Rust-Proofing Corp.

Cement Mortar Lining:
Centriline Corp.
McWane Cast Iron Pipe Co.
Pacific States Cast Iron Pipe Co.

Chemical Feed Apparatus:
Infilco Inc.
Omega Machine Co. (Div., Builders Iron Fdry.)
Permutit Co.
Proportioneers, Inc.
Ross Valve Mfg. Co.
Simplex Valve & Meter Co.
Wallace & Tiernan Co., Inc.

Chemists and Engineers:
(See Prof. Services, pp. 25–29)

Chlorination Equipment:
Builders-Providence, Inc.
Everson Mfg. Corp.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.

Chlorine Comparators:
Hellige, Inc.
Klett Mfg. Co.
Wallace & Tiernan Co., Inc.

Chlorine, Liquid:
Solvay Process Div.
Wallace & Tiernan Co., Inc.

Clamps and Sleeves, Pipe:
James B. Clow & Sons
Dresser Mfg. Div.
M. Greenberg's Sons
James Jones Co.
McWane Cast Iron Pipe Co.
Mueller Co.
Pacific States Cast Iron Pipe Co.
Rensselaer Valve Co.
Skinner, M. B., Co.
A. P. Smith Mfg. Co.
Smith-Blair, Inc.

Clamps, Bell Joint:
James B. Clow & Sons
Dresser Mfg. Div.
Skinner, M. B., Co.
Smith-Blair, Inc.

Clamps, Pipe Repair:
James B. Clow & Sons
Dresser Mfg. Div.
McWane Cast Iron Pipe Co.
Pacific States Cast Iron Pipe Co.
Skinner, M. B., Co.
Smith-Blair, Inc.

Clarifiers:
American Well Works
Belco Industrial Equipment Div.
Chain Belt Co.
Cochrane Corp.
Dorr Co.
Graver Water Conditioning Co.
Infilco Inc.
Permutit Co.
Walker Process Equipment, Inc.

Cleaning Water Mains:
Flexible Sewer-Rod Equipment Co.
National Water Main Cleaning Co.

Condensers:
United States Pipe & Foundry Co.

Contractors, Water Supply:
Layne & Bowler, Inc.

Controllers, Liquid Level, Rate of Flow:
Builders-Providence, Inc.
Infilco Inc.
Simplex Valve & Meter Co.
Sparling Meter Co., Inc.

Copper Sheets:
American Brass Co.

Copper Sulfate:
General Chemical Div.
Phelps Dodge Refining Corp.
Tennessee Corp.

Corrosion Control:
Calgon, Inc.

Couplings, Flexible:
DeLaval Steam Turbine Co.
Dresser Mfg. Div.
Philadelphia Gear Works, Inc.
Smith-Blair, Inc.

Diaphragms, Pump:
Dorr Co.
Morse Bros. Mchy. Co.
Southern Pipe & Casing Co.

Engines, Hydraulic:
Ross Valve Mfg. Co.

Engineers and Chemists:
(See Prof. Services, pp. 25–29)

Feedwater Treatment:
Allis-Chalmers Mfg. Co.
Belco Industrial Equipment Div.
Calgon, Inc.
Cochrane Corp.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.

Ferric Sulfate:
Tennessee Corp.

Filter Materials:
Anthracite Equipment Corp.
Johns-Manville Corp.
Infilco Inc.
Northern Gravel Co.
Permutit Co.

Filters, Incl. Feedwater:
Cochrane Corp.
Dorr Co.
Infilco Inc.
Morse Bros. Mchy. Co.
Permutit Co.
Roberts Filter Mfg. Co.
Ross Valve Mfg. Co.

Filtration Plant Equipment:
Chain Belt Co.
Filtration Equipment Corp.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Omega Machine Co. (Div., Builders Iron Fdry.)
Permutit Co.
Roberts Filter Mfg. Co.
Stuart Corp.
Welsbach Corp., Ozone Processes Div.

Fittings, Copper Pipe:
Dresser Mfg. Div.
M. Greenberg's Sons
Hays Mfg. Co.
James Jones Co.
Mueller Co.

Fittings, Tees, Ells, etc.:
American Cast Iron Pipe Co.
American Locomotive Co.
Carlon Products Corp.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Crane Co.
Dresser Mfg. Div.
James Jones Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
McWane Cast Iron Pipe Co.
Pacific States Cast Iron Pipe Co.
United States Pipe & Foundry Co
R. D. Wood Co.

Flocculating Equipment:
Chain Belt Co.
Dorr Co.
Infilco Inc.
Permutit Co.
Stuart Corp.
Walker Process Equipment, Inc.

Fluoride Chemicals:
American Agricultural Chemical Co.
Blockson Chemical Co.

Fluoride Feeders:
Builders-Providence, Inc.
Omega Machine Co.
Wallace & Tiernan Co., Inc.

Furnaces:
Jos. G. Pollard Co., Inc.

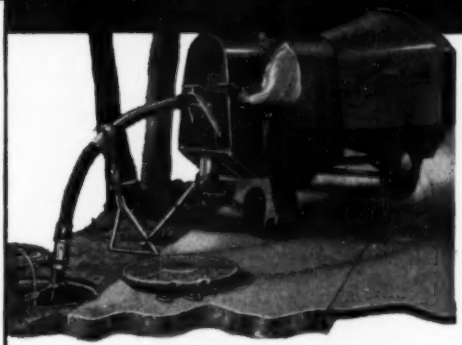
Furnaces, Joint Compound:
Northrop & Co., Inc.

Gages, Liquid Level:
Builders-Providence, Inc.
Infilco Inc.
Simplex Valve & Meter Co.

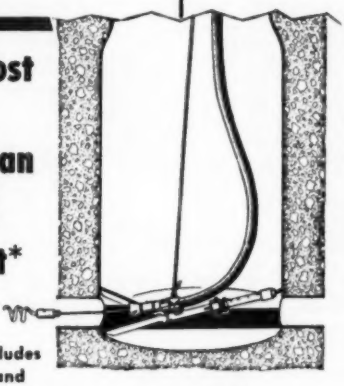
Gages, Loss of Head, Rate of Flow, Sand Expansion:
Builders-Providence, Inc.
Infilco Inc.
Northrop & Co., Inc.
Simplex Valve & Meter Co.
Sparling Meter Co., Inc.

DO YOU REALIZE ?
ONE "FLEXIBLE" SEWERODER

CLEANS 50 BLOCKS OF SEWERS PER WEEK!



At a Cost of Less Than 2¢ a Foot*



*This figure includes maintenance and parts replacement.

SEWERODER

—Is a mechanical marvel that does all rodding with two men—eliminating 9/10ths of the usual hard labor in a day's work. It's increased, low cost capacity permits "preventative maintenance" to be carried on inexpensively—and eliminates costly emergency work. Rod reel contains 900 feet of rods for instant use. Imparts a rotating action to rods and tools. Truck mount models also available.

WRITE today

Flexible

SEWER-ROD EQUIPMENT CO.

9059 VENICE BOULEVARD, LOS ANGELES 34, CALIF.

41 Greenway St. — Hamden 14, Conn.
147 Hillside Terrace — Irvington, N. J.
P. O. Box 465 — Memphis, Tennessee
1115 Delaware Ave. — Fort Pierce, Fla.
141 W. Jackson Blvd. — Chicago, Ill.
200 Magee Bldg. — Pittsburgh, Penn.
66 Kiniry Drive — Rochester 9, New York
29 Cerdan Avenue — Roslindale 31, Mass.
801 E. Excelsior Blvd. — Hopkins, Minn.
3786 Durango St. — Los Angeles 34, Calif.
4455 S.E. 24th Street — Portland, Oregon
351 West Jefferson Blvd. — Dallas, Texas
Francis Hankin — Montreal & Toronto, Canada

AMERICA'S LARGEST MANUFACTURER
OF PIPE CLEANING TOOLS AND EQUIPMENT

Gasholders:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Gaskets, Rubber Packing:
James B. Clow & Sons
Johns-Manville Corp.
Northrop & Co., Inc.
Smith-Blair, Inc.

Gates, Shear and Sluice:
Armco Drainage & Metal Products, Inc.
James B. Clow & Sons
Morse Bros. Mchy. Co.
Mueller Co.
R. D. Wood Co.

Gears, Speed Reducing:
DeLaval Steam Turbine Co.
Philadelphia Gear Works, Inc.

Glass Standards—Colorimetric Analysis Equipment:
Hellige, Inc.
Klett Mfg. Co.
Wallace & Tiernan Co., Inc.

Goosenecks (with or without Corporation Stops):
James B. Clow & Sons
Hays Mfg. Co.
James Jones Co.
Mueller Co.

Hydrants:
James B. Clow & Sons
Darling Valve & Mfg. Co.
M. Greenberg's Sons
James Jones Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Pacific States Cast Iron Pipe Co.
A. P. Smith Mfg. Co.
Rensselaer Valve Co.
R. D. Wood Co.

Hydrogen Ion Equipment:
Hellige, Inc.
Wallace & Tiernan Co., Inc.

Ion Exchange Materials:
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Rohm & Haas Co.

Iron Removal Plants:
American Well Works
Belco Industrial Equipment Div.
Chain Belt Co.
Cochrane Corp.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Welsbach Corp., Ozone Processes Div.

Jointing Materials:
Atlas Mineral Products Co.
Hydraulic Development Corp.
Johns-Manville Corp.
Leadite Co., Inc.
Northrop & Co., Inc.

Joints, Mechanical, Pipe:
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Dresser Mfg. Div.
McWane Cast Iron Pipe Co.
Pacific States Cast Iron Pipe Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Leak Detectors:
Jos. G. Pollard Co., Inc.

Lime Slakers and Feeders:
Dorr Co.
Infilco Inc.
Omega Machine Co. (Div., Builders Iron Fdry.)
Permutit Co.

Magnetic Dipping Needles:
W. S. Darley & Co.

Meter Boxes:
Ford Meter Box Co.
Pittsburgh Equitable Meter Div.

Meter Couplings and Yokes:
Badger Meter Mfg. Co.
Dresser Mfg. Div.
Ford Meter Box Co.
Hays Mfg. Co.
Hersey Mfg. Co.
James Jones Co.
Mueller Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Smith-Blair, Inc.
Welsbach Corp., Kitson Valve Div.
Worthington-Gamon Meter Co.

Meter Reading and Record Books:
Badger Meter Mfg. Co.

Meter Testers:
Badger Meter Mfg. Co.
Ford Meter Box Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.

Meters, Domestic:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Meters, Filtration Plant, Pumping Station, Transmission Line:
Builders-Providence, Inc.
Infilco Inc.
Simplex Valve & Meter Co.
Sparling Meter Co., Inc.

Meters, Industrial, Commercial:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Builders-Providence, Inc.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Simplex Valve & Meter Co.
Sparling Meter Co., Inc.
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Mixing Equipment:
Chain Belt Co.
Infilco Inc.
Walker Process Equipment, Inc.

Ozonation Equipment:
Welsbach Corp., Ozone Processes Div.

Pipe, Asbestos-Cement:
Johns-Manville Corp.
Keasbey & Mattison Co.

Pipe, Brass:
American Brass Co.

Pipe, Cast Iron (and Fittings):
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Crane Co.
McWane Cast Iron Pipe Co.
Pacific States Cast Iron Pipe Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Pipe, Cement Lined:
Cast Iron Pipe Research Assn.
James B. Clow & Sons
McWane Cast Iron Pipe Co.
Pacific States Cast Iron Pipe Co.
Southern Pipe & Casing Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Pipe Coatings and Linings:
The Barrett Div.
Cast Iron Pipe Research Assn.
Centriline Corp.
Koppers Co., Inc.
Pipelife, Inc.
Reilly Tar & Chemical Corp.
Southern Pipe & Casing Co.

Pipe, Concrete:
American Concrete Pressure Pipe Assn.
American Pipe & Construction Co.
Lock Joint Pipe Co.
Universal Concrete Pipe Co.

Pipe, Copper:
American Brass Co.

Pipe Cutting Machines:
James B. Clow & Sons
Ellis & Ford Mfg. Co.
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Pipe Jointing Materials: see Jointing Materials

Pipe Locators:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Pipe, Plastic:
Carlon Products Corp.

Pipe, Steel:
American Locomotive Co.
Armco Drainage & Metal Products Inc.
Bethlehem Steel Co.
Southern Pipe & Casing Co.

Plugs, Removable:
James B. Clow & Sons
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Potentiometers:
Hellige, Inc.

Pressure Regulators:
Allis-Chalmers Mfg. Co.
Mueller Co.
Ross Valve Mfg. Co.

Pumps, Boiler Feed:
DeLaval Steam Turbine Co.

Pumps, Centrifugal:
Allis-Chalmers Mfg. Co.
American Well Works
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Morse Bros. Mchy. Co.

Pumps, Chemical Feed:
Infilco Inc.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.

Pumps, Deep Well:
American Well Works
Layne & Bowler, Inc.

Pumps, Diaphragm:
Dorr Co.
Morse Bros. Mchy. Co.

Pumps, Hydrant:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Pumps, Hydraulic Booster:
Ross Valve Mfg. Co.

Pumps, Sewage:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
Economy Pumps, Inc.

Pumps, Sump:
DeLaval Steam Turbine Co.
Economy Pumps, Inc.

Pumps, Turbine:
DeLaval Steam Turbine Co.
Layne & Bowler, Inc.

Recorders, Gas Density, CO_2, NH_3, SO_2, etc.:
Permutit Co.
Wallace & Tiernan Co., Inc.

FLEXIBLE BOLTED CONNECTION

Savings in joint making time and labor costs, plus leak-proof flexibility, all combine to increase the demand for M & H Gate Valves with Mechanical Joint end connections. M & H Mechanical Joints are made in accordance with A. S. A. standard specifications A21.11, 1952, with glands, gaskets and bolts interchangeable with Standardized Mechanical Joints for cast iron pipe as furnished by all pipe companies who are members of the Cast Iron Pipe Research Association.

This joint uses the stuffing box principle, by which a thick gasket of triangular cross section is compressed into a stuffing box by a bolted follower ring or gland. Mechanical joint making in the field does not require skilled workmen. The joint's flexibility permits deflection in any direction, longitudinal expansion or contraction without leakage.

Mechanical Joint ends are available on all types of M & H Gate Valves, manufactured in accordance with American Water Works Association specifications, sizes 2 to 36 inches. For complete information, write or wire M & H VALVE AND FITTINGS COMPANY, Anniston, Alabama.

M&H PRODUCTS FOR WATER WORKS • FILTER PLANTS INDUSTRY • SEWAGE DISPOSAL AND FIRE PROTECTION

Recording Instruments:
Infilco Inc.
Sparling Meter Co., Inc.
Wallace & Tiernan Co., Inc.

Reservoirs, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Sand Expansion Gages; see Gages

Sleeves; see Clamps

Sleeves and Valves, Tapping:
James B. Clow & Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Sludge Blanket Equipment:
Permutit Co.

Soda Ash:
Solvay Process Div.

Sodium Hexametaphosphate:
Blockson Chemical Co.
Calgon, Inc.

Softeners:
Belco Industrial Equipment Div.
Cochrane Corp.
Dorr Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Softening Chemicals and Compounds:
Calgon, Inc.
Infilco Inc.
Permutit Co.
Tennessee Corp.

Standpipes, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:
American Locomotive Co.
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Stops, Curb and Corporation:
Hays Mfg. Co.
James Jones Co.
Mueller Co.
Welsbach Corp., Kitson Valve Div.

Storage Tanks; see Tanks

Strainers, Suction:
James B. Clow & Sons
M. Greenberg's Sons
Johnson, Edward E., Inc.
R. D. Wood Co.

Surface Wash Equipment:
Permutit Co.

Swimming Pool Sterilization:
Everson Mfg. Corp.
Omega Machine Co. (Div., Builders Iron Fdry.)
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Tanks, Steel:
American Locomotive Co.
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Tapping Machines:
Hays Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.
Welsbach Corp., Kitson Valve Div.

Taste and Odor Removal:
Industrial Chemical Sales Div.
Infilco Inc.
Permutit Co.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Hellige, Inc.
Wallace & Tiernan Co., Inc.

Turbines, Steam:
DeLaval Steam Turbine Co.

Turbines, Water:
DeLaval Steam Turbine Co.

Valve Boxes:
James B. Clow & Sons
Ford Meter Box Co.
M & H Valve & Fittings Co.
Mueller Co.
Pacific States Cast Iron Pipe Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valve-Inserting Machines:
A. P. Smith Mfg. Co.

Valves, Altitude:
Davis Mfg. Co.
Ross Valve Mfg. Co., Inc.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
James B. Clow & Sons
Crane Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
Belco Industrial Equipment Div.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Davis Mfg. Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Valves, Float:
James B. Clow & Sons
Davis Mfg. Co.
Ross Valve Mfg. Co., Inc.

Valves, Gate:
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Dresser Mfg. Div.
James Jones Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Pacific States Cast Iron Pipe Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Davis Mfg. Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Davis Mfg. Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Regulating:
Crane Co.
Davis Mfg. Co.
Mueller Co.
Ross Valve Mfg. Co.

Valves, Swing Check:
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Waterproofing
Inertol Co., Inc.

Water Softening Plants; see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
Hellige, Inc.
Wallace & Tiernan Co., Inc.

Water Treatment Plants:
Allis-Chalmers Mfg. Co.
American Well Works
Belco Industrial Equipment Div.
Chain Belt Co.
Chicago Bridge & Iron Co.
Cochrane Corp.
Dorr Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Well Drilling Contractors:
Layne & Bowler, Inc.

Well Screens
Johnson, Edward E., Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite; see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1953 AWWA Directory.

DE LAVAL
FIRE PUMPS

on the job at Idlewild

Ten De Laval centrifugal pumps, with a total capacity of 34,000 gpm, play a vital role in the deluge fire-fighting system of the New York International Airport at Idlewild, Long Island.

The installation is composed of two 2,500 gpm and three 4,000 gpm motor-driven pumps as well as two 2,500 gpm and three 4,000 gpm diesel-driven units, which are used for standby service. When the normal operating pressure drops from 165 psi to 140 psi or less, the electric pumps go to work automatically. The diesels are brought into service as necessary.

Efficient De Laval centrifugal pumps are serving water works and fire-fighting stations all over America. These pumps are available in capacities ranging from less than one million gallons per day to more than 100 million gallons per day.

DE LAVAL *Centrifugal Pumps*

DE LAVAL STEAM TURBINE COMPANY
822 Nottingham Way, Trenton 2, New Jersey

DL 1774

30 YEARS GIVE PROOF *of Dependability!*

WRITES: *J. F. Bearden, Superintendent, Department of Water Supply, Walhalla, South Carolina.*

J. F. BEARDEN
SUPERINTENDENT

Town of Walhalla
Department of Water Supply
WALHALLA, S. C.

September 3, 1952

Mr. C. F. McAuley
Rockwell Manufacturing Company
1495 Northside Drive, N.W.
Atlanta 1, Georgia

Dear Mac:

On October 1, I bring to an end my 30 years of service as Superintendent of Water Supply for the Town of Walhalla. Though I will no longer take an active part, City Council has requested that I serve in an advisory capacity to the department.

I am taking this opportunity to express to you and the entire Rockwell organization my grateful thanks for the cooperation and service extended me.

I recall the day I placed my first order for Pittsburgh Meters with your Mr. Taylor. That was 30 years ago. When you have exclusively used a product for that long, you really appreciate the quality and dependability built into your meters and I have never once had reason to question my choice.

Mr. C. L. Walling, Assistant Superintendent since 1938, has been designated as my successor. I am glad to state that Mr. Walling will continue to use your meters because of their proven merit and performance.

In closing, may I again express my gratitude for the years of courteous service. To you and your entire organization my best wishes for continued success.

Sincerely,

J. F. Bearden

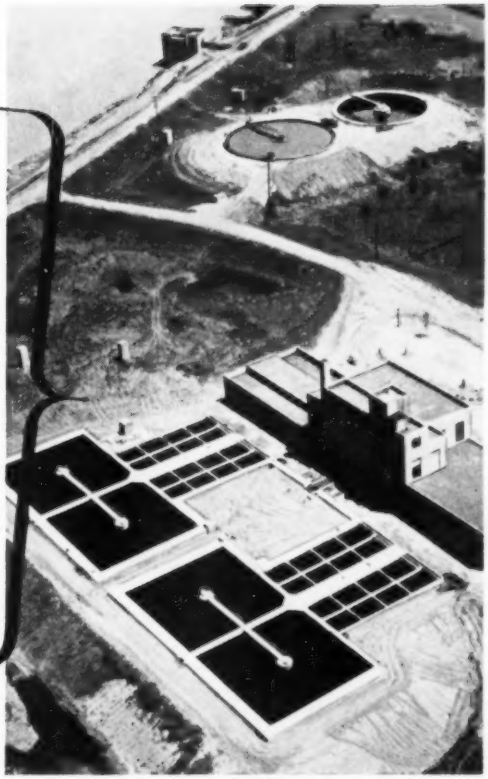
J. F. Bearden

The Symbol for Service, Quality and Performance in Water Meters

ROCKWELL MANUFACTURING COMPANY

PITTSBURGH 8, PA. Atlanta Boston Chicago Houston Los Angeles
N. Kansas City New York Pittsburgh San Francisco Seattle Tulsa

It takes more than a "Magic Formula" for water treatment at Council Bluffs



Consulting Engineers: Burns & McDonnell Engineering Co., Kansas City, Missouri.

There is no "magic formula" for solving your water treatment problem. The answer must be found by an analysis of the variables . . . raw water composition, rate of flow, results required and local conditions.

Taming the "Big Muddy," making Missouri River water usable, called for an analysis by the consulting engineers of the specific problem at Council Bluffs, Iowa.

Solution is the 16 MGD water treatment plant shown here. Presedimentation, where approximately 95% of the turbidity is removed, is handled by two 100′ dia. Dorr Presedimentation Clarifiers shown at the top of the photo. Following addition of chemicals, major treatment takes place in a unique and efficient arrangement of parallel or series units, each including two Dorrco Flocculators in a basin approximately 60′ x 73′, followed by quiescent sedimentation in two 70′ Dorr Squarex Clarifiers. One Dorrco Flash Mixer is used at the head end of the first stage, another of the low lift type for the second stage when operated in series.

A unique feature of the Presedimentation Clarifiers is a specially designed "ice hood" supplied for cold weather operation. The influent area is covered so that in winter months heat can be introduced to effectively prevent any ice formation.

Every day, nearly 8 billion gallons of water are treated by Dorr equipment.

*Flocculator and Squarex are trademarks of The Dorr Company, Reg. U. S. Pat. Off.

Better tools TODAY to meet tomorrow's demand

DORR

WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT

THE DORR COMPANY • ENGINEERS • STAMFORD, CONN.

Offices, Associated Companies or Representatives in principal cities of the world

LEADITE

Trade Mark Registered U. S. Pat. Office

Jointed for . . . Permanence with LEADITE

Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%

THE LEADITE COMPANY
Girard Trust Co. Bldg. Philadelphia, Pa.

No Caulking